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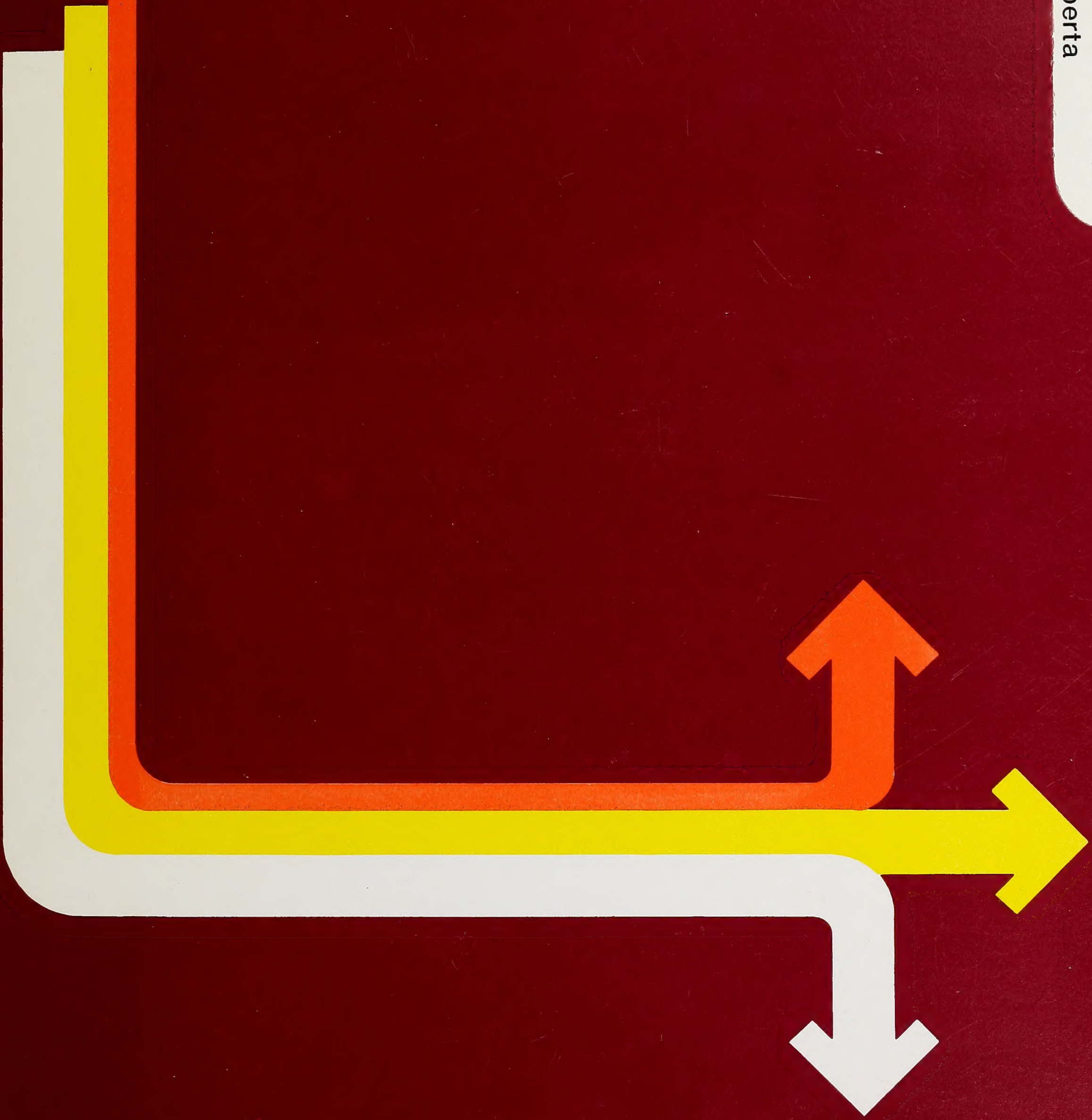
3 Energy Efficient Subdivision in Alberta



planning forum

Planning Forum

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The Planning Forum Series is designed to place before decision-makers in government and the private sector innovative ideas, explorations, case studies and discussions related to improving the development of policy and the making of decisions in the land use planning field. Since the purpose of the Series is to stimulate, to contribute to the free exchange of ideas, reports may cover a broad — and sometimes unconventional — range of philosophies and approaches.

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3 Energy Efficient Subdivision
in Alberta

Energy Efficient Residential Subdivision Development in Alberta

The Planning Forum Series
3

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January, 1985

Energy Efficient
Residential Subdivision Development
in Alberta

by

John F. McLaughlin, MCIP

edited by

Timothy B. Yip, MCIP

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About the Author

John F. McLaughlin is currently a Project Manager with The City of Edmonton's Real Estate and Supply Services Department. He has been active in the energy field since 1978 and has published papers on energy and water conservation. Mr. McLaughlin received a B.Sc. (Recreation) from the University of Ottawa and a Master in Environmental Design (Urban and Regional Planning) from the University of Calgary. Mr. McLaughlin's most recent involvement in energy is his participation on the management board for the Edmonton Energy Conservation Centre which is a City-owned house (and the first of its kind in Alberta) being renovated to demonstrate efficient energy management.

INTRODUCTION

This paper describes strategies that can be employed to reduce the amount of energy used for space heating and transportation in new residential subdivisions. Examples of Canadian communities using or considering these strategies are cited; most examples are from the Edmonton region. (Although the original research was conducted in 1981, the information for some of these examples was updated in the Fall of 1984.) Strategies are presented in six categories - solar access, wind protection, density, building and land use mix, transportation, and district heating.

This first two sections examine how residential energy use is affected by the development site and micro-climate. The main site considerations are topography, building orientation, wind, and vegetation.

Site selection and design for residential development are closely related when undertaking energy analysis. Sites with features that will result in reduced energy use are preferred. On any particular site, there are opportunities for minimizing the energy use of a development by changing traditional siting and layout patterns and by enhancing the natural environment.

Some of the information useful for energy sensitive site analysis and design is:[1]

- areas protected by topography or vegetation by time of day or season;
- slope orientation and vegetation type/extent;
- areas exposed to sun or wind by time of day/season;
- daily, monthly and seasonal solar patterns;
- daily, monthly and seasonal wind patterns;
- daily, monthly and seasonal temperature patterns; and
- frost pockets, snow drift, and collection patterns.

Using this and other data, activities and structures can be located on the site to minimize energy use. Preferred sites are located about halfway up a slope for wind protection, out of frost pockets, and oriented in a south to southeast direction to optimize solar gain.

1. SOLAR ACCESS

Solar Systems for Alberta Housing

Solar energy is best suited to low temperature heating requirements, typical of space heating. Alberta's climate, particularly in the southern region with an extensive cold heating season but with abundant sunshine, is well suited to solar applications. Alberta is one of the sunniest provinces in Canada, averaging 2200 - 2300 hours of bright sunshine annually.[2]

For a 100 m^2 (plus basement) new home on the Prairies, pre-1975 annual space heating requirements averaged 150 - 200 GJ. This space heating requirement can be reduced by 90% to 5-20 GJ/a[3], based upon a passive solar energy system and a full energy conservation package.

A full energy conservation package includes: high insulation levels, air tightness, and an air-to-air heat exchanger. A large area of shuttered south-facing windows is the major part of a passive solar system. This has major implications for subdivision design, lot and building orientation and protection of solar access. In 1979, Saskatchewan builders were producing energy efficient and passive solar housing for an additional $3,000 to $4,000 on an average-size house.[4]

The federal government is currently sponsoring the R2000 Program which provides incentives for builders to construct energy efficient dwellings. The average incremental cost of these homes across Canada is $5,800. About 40 of these dwellings have been built in Alberta in 1983-84. Performance data should be available in January, 1985.[5]

In 1980, the Saskatchewan and Alberta governments jointly published "Energy Efficient Housing - A Prairie Approach". It did not recommend the use of active solar systems for space heating because it is uneconomical. Once space heating requirements are reduced through efficient construction techniques and optimizing passive solar gain, the cost of adding an active solar system exceeds the benefits. However, because hot water heating is required year round and because relatively inexpensive solar hot water heating systems are available and can be built by do-it-yourselfers, active solar systems are generally more economical for water heating than space heating.

In using a combination of energy efficient and passive solar construction techniques, a general rule of thumb is - "Use Insulation Before Insolation."

> In an ordinary house, sun shining through south-facing windows during the winter months does not reduce the fuel bill by more than about 1%. In an energy-efficient house, however, the solar gain from these windows can provide a very substantial part (30% or more) of the heating load. With shutters on a south-facing window, you have a low-cost solar heating system.[6]

Many recently built passive solar homes have the appearance of conventional houses (unlike early solar homes) which facilitates their marketability.

A number of passive solar homes[7] have been built throughout Alberta and are operating successfully. Five energy efficient houses were featured in the Housing and Urban Development Association of Canada's (HUDAC) show homes in Calgary and Edmonton in 1981. These were built as part of the Energy Saver Program, a voluntary program using energy guidelines from the National Building Code and HUDAC research.[8] Nu West Development Corporation constructed a demonstration passive solar home in St. Albert, Alberta. The home incorporates conservation techniques and passive solar features: south-facing windows with insulated shutters, insulated south-facing French doors, and thermal mass within interior walls. The house was projected to use only 20% to 25% of the natural gas normally used for space heating. The University of Alberta projected costs and savings for the house and concluded that the payback period for conservation features would be about six years.[9]

Legal Protection of Solar Access

Presently, Alberta inhibits the right to light by law. The right to unobstructed sunlight by prescriptive easement has been explicity set aside by Section 50 of the Limitations of Action Act. However, there are at least three approaches available in Alberta to protect solar access: solar express easements between individual land owners, developers' use of restrictive covenants, and municipal land use bylaws[10], each described below.

An 'easement' is a right of one land owner to use the land of another for a special purpose. Solar express easements would be granted by a land owner who would explicitly agree not to block a neighbour's access to sunlight.

To use restrictive covenants, developers could, in the Certificate of Title, write restrictions on building set-back and height which would guarantee solar access for north-side neighbours. A municipality, when negotiating the development agreement, could encourage or offer incentives to the developer to use restrictive covenants.

The use of the municipal land use bylaw could be the most effective approach to protecting solar access. Designated districts could restrict building height, set-back, orientation, and vegetation to create solar zones. Two innovative approaches are especially useful for protecting solar access - three dimensional envelopes, and Planned Unit Developments (PUD). The major advantages and disadvantages of each approach are presented in Table 1.

Table 1

TOOLS TO PROTECT SOLAR ACCESS IN ALBERTA

TOOL	MAJOR ADVANTAGES	MAJOR DISADVANTAGES
Solar Express Easements, by Owners	Immediately usable, no legislation needed	Voluntary nature Expense of an agreement
Restrictive Covenants, by Developers	Low Cost Familiarity of use for other purposes Flexibility-restrictions can vary from lot to lot Immediately usable, no legislation needed	Initial implementation rests with land owners and enforcement rests with neighbours outside municipal control
Land use Control Bylaw, by Municipality	Familiarity of use for other purposes Costs are distributed equitably Flexibility-adaptable to local conditions Information is accessible to public	Places heavy burden on municipality to implement and enforce, requiring interest and expertise

Even though there are tools available in Alberta to protect solar access without changing provincial law, legislation would increase public awareness and provide a more certain legal footing from which to launch protective measures. For example, an amendment to the Planning Act could enable land use bylaws to be used for the purpose of solar access protection. Currently, the Act does not prohibit land use bylaws from doing this. Since there has been no case law in Alberta concerning sunlight access, and since The Limitations of Action Act places it in a subordinate legal position, one could assume there is no legal access to light, thus discouraging the development of solar assisted buildings.

Subdivision Design Implications of Solar Access

When considering the use of solar energy, subdivision designers should concentrate in the short term on direct, passsive solar applications because they are more economically feasible than active systems.

A successful solar subdivision requires:

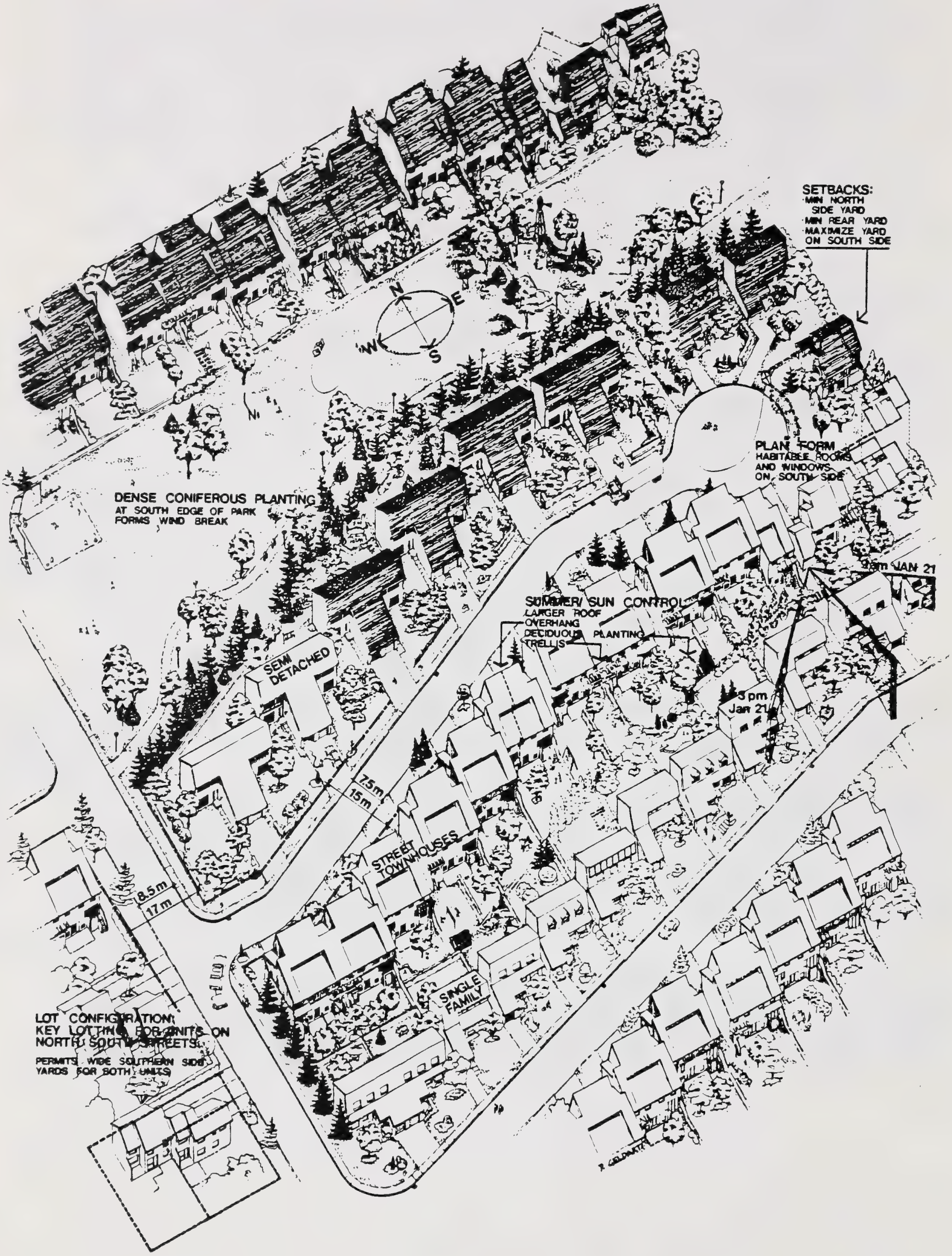
- placing the long axis of the buildings in an east-west direction for maximum exposure
- placing most of the windows on the south side
- constructing roofs with a broad southern explosure at an optimum angle to the sun (latitude +15 degrees for future addition of active systems), and
- providing for summer shading, except for water heating systems[11].

These requirements, in turn, affect: house design, lot shapes, building heights, set-backs, street orientations, and landscaping, which should incorporate solar design at an early stage.

Streets in an east-west direction permit a southern exposure to a maximum number of dwelling units. To maintain solar access, minimum street widths need to be adopted. These depend on latitude, building heights, lot depths and set-back standards in the community. An example of a solar oriented subdivision is shown in Figure 1.

Because of the extensive implications of solar energy for subdivision design, the early consideration of solar access in the subdivision process is important. This analysis should begin at the block level, progress to the neighbourhood, and then to the area.

figure 1 subdivision design for passive solar gain


SETBACKS:
·MIN NORTH SIDE YARD
·MIN REAR YARD
·MAXIMIZE YARD ON SOUTH SIDE
N
E
W
S
PLAN FORM
HABITABLE ROOMS AND WINDOWS ON SOUTH SIDE
DENSE CONIFEROUS PLANTING
AT SOUTH EDGE OF PARK FORMS WIND BREAK
9am JAN 21
SUMMER/ SUN CONTROL
LARGER ROOF OVERHANG
DECIDUOUS PLANTING
TRELLIS
SEMI DETACHED
3 pm Jan 21
7.5m
15m
STREET TOWNHOUSES
8.5m
17m
SINGLE FAMILY
LOT CONFIGURATION:
KEY LOTTING FOR UNITS ON NORTH SOUTH STREETS.
PERMITS WIDE SOUTHERN SIDE YARDS FOR BOTH UNITS

Although a due south building orientation is optimum for the operation of a solar heating system, its performance is not significantly affected by variations of less than about 15 degrees from due south.[12] Streets 15 to 30 degrees off the east-west axis can still be effective for orienting homes to the south by angling their placement on the lot and using a variable set-back (see Figure 2).

To provide access to the sun, some spacing between buildings is required - the further north, the lower the sun and the greater the spacing required. Multipliers per unit object height for shadow length in major Canadian cities are shown in Table 2. The table can be used to determine the maximum shadow length of any object, by multiplying the height of the object by the multiplier, for the City closest to your location.

Table 2

HORIZONTAL NORTHWARD SHADOWS AT NOON, DECEMBER 21

CITY	LATITUDE (°N)	SOLAR ALTITUDE (°)	SHADOW LENGTH PER UNIT OBJECT HEIGHT
Toronto Windsor	43	23.6	2.3
Vancouver Winnipeg	49	17.6	3.2
Calgary Regina	51	15.6	3.6
Edmonton Saskatoon	53	13.6	4.1

Source: Beverly E. Robertson, ed., Energy and Community Planning On The Prairies, Proceedings of a Symposium Held in Regina, May 10-12, 1979, (Canadian Plains Research Center, University of Regina: Regina, 1980), p. 204.

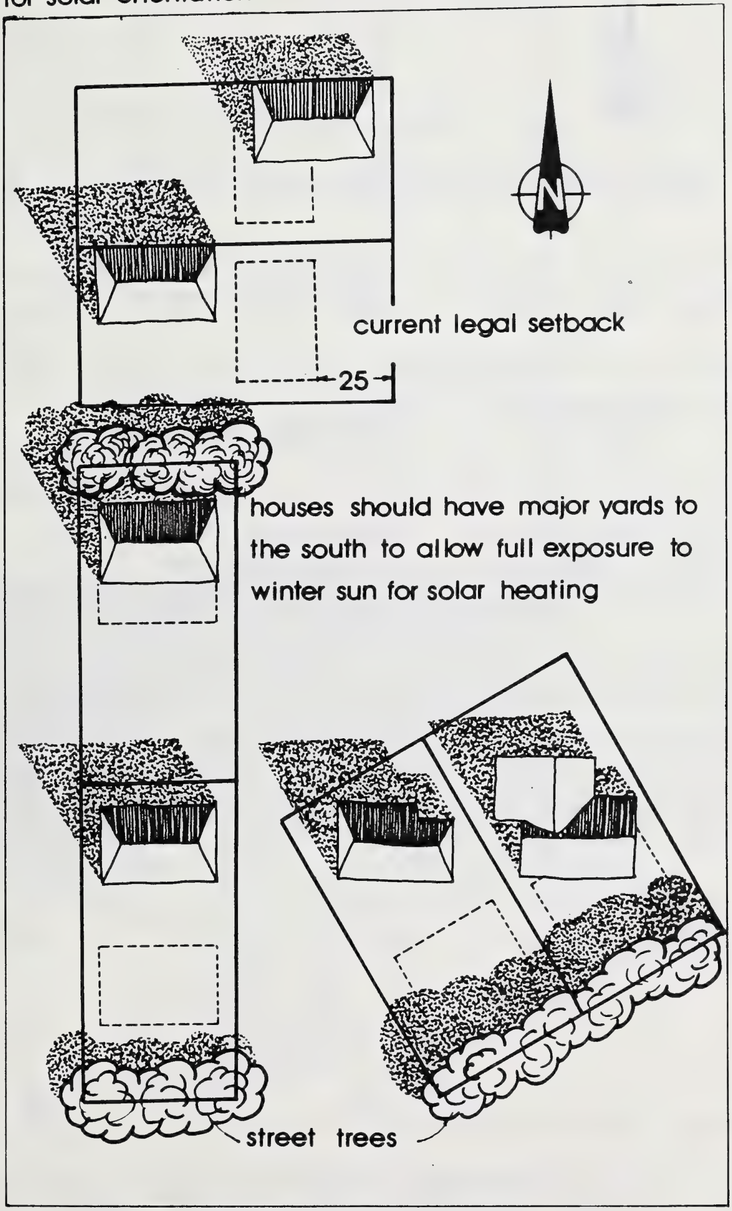
With Alberta's northerly latitudes, building spacing must be sufficient to prevent winter shadowing. Nevertheless, densities could still exceed the norm commonly achieved in new subdivisions of 12 - 15 units per hectare.[13] Roof-top active solar systems require less solar access than wall/window passive systems, since the area requiring sunlight is higher and not subject to as much shading as a wall. To avoid higher buildings shading lower buildings, building heights should be gradually increased from south to north.

Household-scale solar systems can be more effective at higher densities, because attached multi-family units have lower heating needs, allowing solar systems to contribute to a greater proportion of the heating load.

The orientation of apartment buildings is a major factor in their energy use. Data from Kitchener, Ontario indicates that new apartment buildings could reduce energy use by up to 60% by maximizing solar gain. This is achieved by changing the building's long axis from a north-south to an east-west orientation.[14]

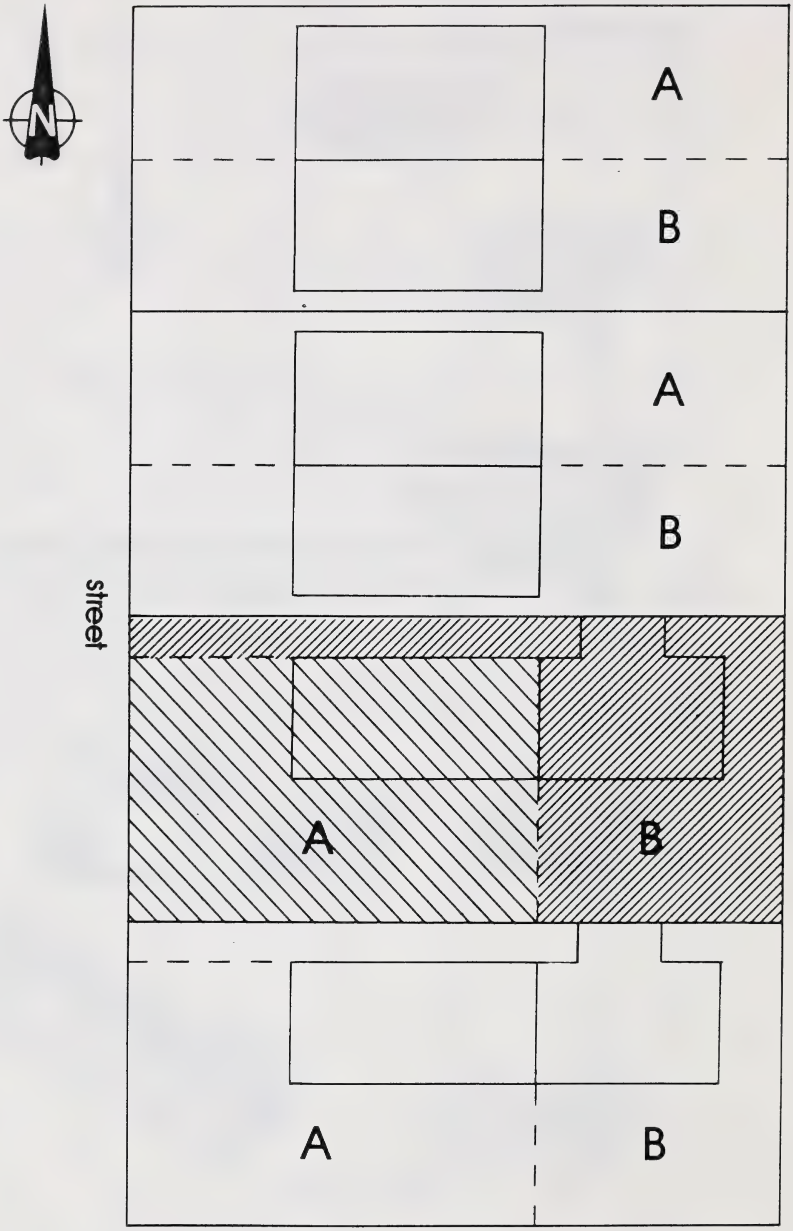
Although conventional zoning and land-use controls do not prevent planning for solar gain, they do not encourage it either. Zero lot-line design, innovative lot shapes, and siting provisions would provide opportunities for solar sensitive building designs, as illustrated in Figures 2 and 3. In general, variety and flexibility in lot shapes and building siting is needed, such as L-shaped lots, key lots, and wider lots on north-south streets. To maximize passive solar gains on narrow south-facing lots, parking garages should be located on north facades.

figure 2 positioning detached housing for solar orientation


N
current legal setback
25
houses should have major yards to the south to allow full exposure to winter sun for solar heating
street trees

SOURCE: Living Systems Inc., Davis Energy Conservation Report, (City of Davis: Davis, California, 1977), P. 39.

figure 3 lot planning for solar oriented duplex housing


standard side-by-side lot and house arrangement
modified back-to-front house and lot arrangement using key lots
N
street
A
B
A
B
A
B
A
B

After: Henry Fliess and Partners, Subdivisions and Sun, (Ontario Ministry of Energy: Toronto, 1980).

Guidelines for the layout of lots and the siting of house types for optimal solar gain are presented in Table 3. Figure 1 is a conceptual design of a subdivision using these guidelines.

Table 3

LOT LAYOUT & HOUSE POSITIONING FOR PASSIVE SOLAR

LOT & HOUSE TYPE	EAST - WEST STREETS	NORTH - SOUTH STREETS
Single Family	Wider lots on north; Narrow, deep lots on south.	Staggered house siting on both sides.
Semi-Detached	Side-by-side units on south side, on narrow lots. Side-by-side units on north side, on wider lots.	Rear-to front units, using key lots and zero lot lines on both sides
Street Townhouses	South side preferred location. Courtyard units on north side.	Design wider units on wider lots, with 2nd. floor solar access. On north-south cul-de-sacs, locate units at south end.
Apartments	Locate on south side of major, wider arterial roads. Locate on north side of streets with parks or open space to the north.	Locate at the south end of north-south cul-du-sacs.

After: Henry Fliess and Partners, Subdivisions and Sun, (Ontario Ministry of Energy: Toronto, 1980).

2. Landscaping and Wind Protection

Landscaping can contribute to energy use reduction by providing: wind protection (which reduces a building's heat load), snow control, improvements to the pedestrian environment, and by preserving solar access.

During site preparation and construction, as much vegetation as possible should be preserved. Windbreaks can be constructed with trees, shrubs, earth berms, walls, fences, and other buildings. The effectiveness of a windbreak is briefly discussed below.

Windbreaks can reduce a building's heat load by diverting air currents upward and by reducing wind speeds on both sides of the wind barrier. In Bates's study [15], a 34% reduction in space heating fuel was found possible.

The percentage of wind reduction at various distances is shown in Table 4. The optimum distance from the windbreak to the area or building to be protected is between one and four times the height of the windbreak, depending upon its density. The denser the windbreak, the closer on the leeward side of the windbreak is the most protected area.[16]

Table 4

WIND REDUCTION AS A FUNCTION OF DISTANCE FROM BARRIER

DISTANCE	REDUCTION %
15H windward	0
0H windward	30
0H leeward	40
5H leeward	60
10H leeward	40
20H leeward	25
40H leeward	0

H = Barrier height

Source: C.G. Bates, "Shelterbelt Influences II, Value of Shelterbelts in Home Heating", J. of Forestry, 43:176-196, 1945.

Density of Windbreak

In general, the more penetrable a windbreak, the longer the protected area. Therefore, moderate density is favoured for extensive sheltering as shown in Table 5. For intensive shelter over a short distance, a dense windbreak is preferable.

> The optimum density for a shelterbelt is about 50% to 60%. This means that the leaves, branches, twigs, and trunks should cover 60% of the frontal area of the belt.[17]

Table 5

WIND REDUCTION TO LEEWARD OF 9 METRE HIGH SHELTERBELTS OF DIFFERENT DENSITY

	Average Percentage Reduction in Wind Speed			
Density	First 45.7 m	First 91.4 m	First 137.1 m	First 274.2 m
Very open	18	24	25	18
Open	54	46	37	20
Medium	60	56	48	28
Dense	66	55	44	25
Very Dense	66	48	37	20

Source: Charles McLenon, ed., Landscape Planning For Energy Conservation (Environmental Design Press: Washington, D.C., n.d.), p. 31.

Shape and Profile of Windbreak

With increased tree height, trees become more open near the ground. As the air stream is forced beneath the tree canopy and through the tree trunks, wind speed increases. Additional rows of trees or shrubs can be used to block these open spaces.[18] An irregularly shaped windbreak, comprised of a mixture of species and sizes of plants, produces a rough upper surface and is therefore more effective in wind control. However, a wind break is more effective if its leading edge is closer to being vertical rather than being gradually pitched.[19]

Fences and Walls as Windbreaks

Fences and walls can provide privacy, security, and wind protection. An open space at the bottom of a solid fence reduces the reverse air flow formed on the leeward side. Walls can be either freestanding or retainers, which hold back a section of earth.[20] Noise attenuation devices (in the form of fences, beams or walls) along major transportation routes might be planned to serve the dual purpose of wind protection if oriented correctly.[21]

Orientation of Windbreak

Windbreaks should be located perpendicular to the direction of the wind. However, the direction of the prevailing wind in a region does not mean the wind will blow in that direction on a specific site. Buildings, hills and vegetation can re-direct wind flow as well as baffle it. Wind flow is complex and provides a major challenge for designers. Simulation techniques are now available for siting and designing buildings [22] to minimize wind impact.

Other Wind Protection Strategies

In some cases, site designers should orient the building, in combination with using windbreaks, to minimize the force of the wind.

> Buildings that are positioned perpendicular to the wind direction receive its full force; at 45 degrees, the force is reduced by 50%.[23]

To minimize the necessity for outside wind protection, interior spaces such as garages, hallways and storage should be located on the north wall, with no or small windows, high insulation levels, and well sealed vapor barriers. Alternately, earth can be bermed against the north wall or the structure can be built into the side of a south-facing slope.

Landscaping for Solar Access

Deciduous trees and shrubs block solar radiation in the summer but allow the winter sun to penetrate and are therefore preferred where solar access is desirable. Deciduous vegetation located south of passive solar gain areas should have low branch density and small size to admit maximum winter sunshine. Architectural overhangs or adjustable awnings can also be used to block the high summer sun from south-facing windows.

Coniferous windbreaks have the least negative impact on solar access if located on the southern edge of open spaces such as streets, alleys, parks, and parking lots.

Snow Management

Effective snow control involves preventing drifts from forming in specific locations. This minimizes snow removal costs and improves the pedestrian environment. Critical locations to protect from snow are: pedestrian routes, roads, entrances and mechanical intakes for buildings. Ways to protect these areas include modifying the building form, details, orientation, and the addition of snow control devices such as landscaping, walls, berms, or fences.[24]

Snow fences or vegetation can be used to control snow which would otherwise accumulate in unwanted locations. Snow fences should be placed at right angles to the prevailing wind (about 18 m to the windward side of the area being protected). A standard slatted wood fence of 1.8 m will form a drift on its leeward side about ten times its height.[25]

Snow fences are not suitable along most urban transportation routes because of the built-up nature of adjacent lands. Road design, however, can minimize drifting by following some basic principles:

- streamline slopes on road embankments,
- construct roads higher than the snow depth for flat areas, and
- when roads are perpendicular to drift-producing winds, design embankments about 20% higher than for roads parallel to the wind direction.[26]

The design and placement of vegetation to protect buildings from heat loss due to winds may conflict with the desire to keep snow away from buildings, since slowing the wind will cause snow to accumulate. This potential trade-off needs to be assessed on any site, and the assessment is made easier with new simulation technology.

Scale of Implementation

Wind protection can be implemented at many development scales - the lot, building cluster, block or neighbourhood. The effects of wind on a cluster of townhouses has been examined and it was found that heating costs for the windward side units were about 5% greater than for leeward side.[27]

At the community level, a wind protection strategy is in place in Fairmont, Quebec. There, a five storey apartment building on the north and west sides of the townsite breaks the prevailing wind. The force of the wind is not fully regained for 0.6 km past the structure.[28]

Potential Heating Savings From Windbreaks

The largest reduction in heat loads occur for the highest wind speeds, as shown in Figure 4. For a 16 km/h wind, the reduction in heating load is about 15%, whereas in a 40 km/h wind, the reduction is about 32%. Sites needing the most wind protection are: open plains, hilltops, and some mountain gaps or narrow valleys where winds accelerate.[29]

Average wind speeds for the core heating season, October to April, have been analyzed for 19 of the largest Alberta communities. The results are presented in Table 6. Conclusions from this analysis are:

1. Average estimated wind speed during the seven coldest months of the year for 19 of the largest communities in Alberta is 13.7 km/h.

2. Communities above this provincial average are Lethbridge, Pincher Creek, Medicine Hat, Calgary, Coronation, Red Deer, Edmonton, Cold Lake and Brooks. These are the communities where protecting homes from winds will result in the greatest energy savings.

3. Generally, wind speeds increase as one moves from northern to southern Alberta.

4. For the estimated provincial average wind speed (during the heating season) of 13.7 km/h, heat loads could be reduced by up to 10%-15%. With a conservative assumption of a 50% protection factor for windbreaks, heat loads could be reduced by about 8%.

Table 6

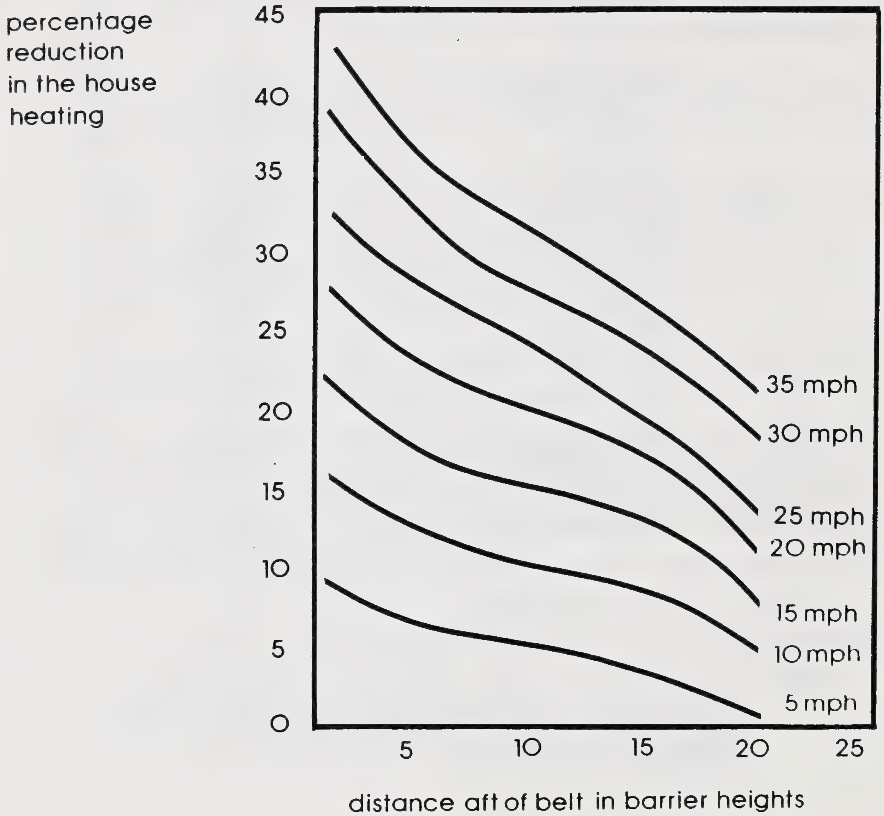
AVERAGE WIND SPEED OCTOBER TO APRIL INCLUSIVE IN SELECTED ALBERTA COMMUNITIES

(Kilometres per hour)

Rank	Community Name	Wind Speed
1	Lethbridge	23.56
2	Pincher Creek	22.27
3	Medicine Hat	16.51
4	Calgary	16.33
5	Coronation	15.94
6	Red Deer	14.61
7	Edmonton	14.22
8	Cold Lake	14.06
9	Brooks	13.96
10	Grande Prairie	13.57
11	Vermilion	12.82
12	Peace River	12.13
13	Fairview	10.63
14	Lac La Biche	10.58
15	Edson	9.98
16	Fort McMurray	9.84
17	Whitecourt	9.84
18	Lacombe	9.84
19	Fort Vermilion	9.34
1-19	All of the above	13.69

After: J. Hawrelak et al., "Appendix B - Mean Monthly Wind Speeds For Selected Locations in Alberta", Wind Power in Alberta (Alberta Research Council: Edmonton, 1976).

figure 4 relationship between wind speed and heat load reductions from wind barrier



3. DENSITY

Introduction

In general, energy consumption decreases as the density of the urban settlement increases. The most important reasons for this inverse relationship are:[30]

1) Central mechanical/electrical systems offer economies of scale;

2) Shared walls and reduced surface areas reduce heat loss;

3) Infrastructure requirements (roads, sewer, water, power, gas, etc.) reduce indirect energy used in construction;

4) Shorter street lengths reduce direct energy used for municipal services - street lighting, snow removal, street maintenance, police patrol, bus service, waste collection and private travel;

5) High concentrations of users contribute to the feasibility, efficiency, and service levels of public transit;

6) Facility concentration encourages the use of other efficient travel modes such as ride sharing, walking and bicycling;

7) Conglomeration of consumers facilitates greater mixing of land uses to reduce travel requirements; and

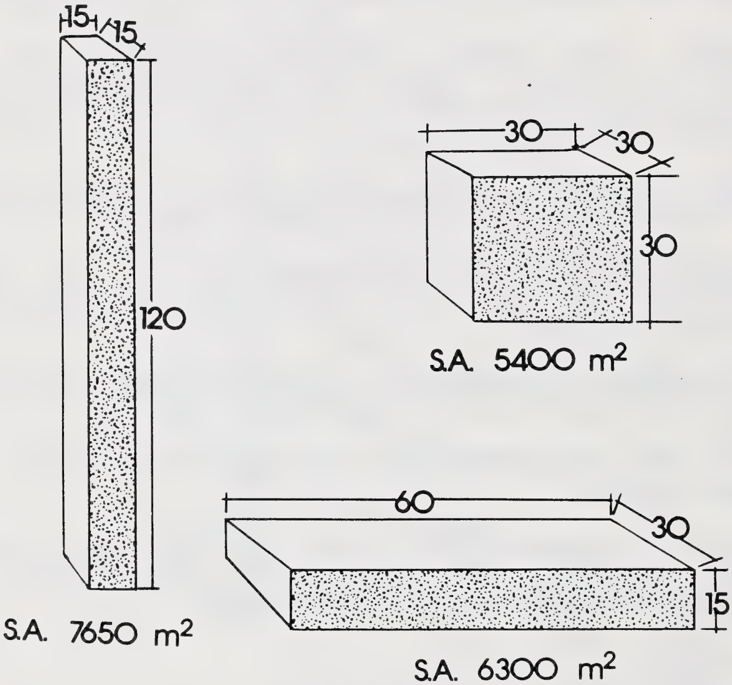
8) Newer efficient technologies, such as district heating, are more viable.

This section will concentrate only on the potential direct energy savings for residential space heating and travel within the subdivision, be increasing density (2 and 4 above).

Optimum Densities

Can an optimum density be defined for buildings? First, the surface-to-volume ratio should be minimized. This results in shorter buildings, with the long axis on the horizontal rather than the vertical plane (Figure 5). High-rises have relatively high heat losses because of their greater surface-to-floor area ratios. Other potential negative externalities of high-rises are wind tunnelling and shading, which can increase energy consumption in neighbouring buildings and degrade the pedestrian environment.

figure 5 building shape versus envelope heat gains and losses (dimensions are in metres)



volume and floor area are constant
surface area varies as indicated

However, increased land coverage with lower buildings (to reduce exposed surface area) results in greater street lengths and reduces community density. Because of the energy trade-off between land coverage and building shape, there is still uncertainty regarding what the optimum building density is. A greater reliance on solar energy would favour medium density, low-rise housing because solar access is needed.

Energy and Dwelling Density

Compared to similar sized detached housing, semi-detached housing uses about 20% less energy; internal units of a two-storey townhouse block use about 40% less energy than a detached house, and energy used in heating apartment units (more than 2 sides attached) uses about 50% less energy.[31]

Energy savings for private travel, municipal vehicular services and street lighting are also significant when examined for a higher density subdivision over a long period. This is because increased density results in shorter street lengths per capita.

Increasing Detached Housing Densities

Zero lot lines reduce the size of the property by eliminating or reducing the size of side, front, or rear yards. This increases neighbourhood density and shortens street lengths per capita, thereby reducing the energy used for transportation. More detailed planning is required for zero lot line developments because of the need to provide visual privacy, sound proofing, and high design standards necessary for successfully marketing. Reducing lot sizes also result in lowered costs for road dedication and servicing.

A recent study on modified lot and street standards in Lethbridge concluded that:

a) Laneless neighbourhoods with a 15 m standard road width (compared to current standards of 17-18 m, with lanes) increase net density by 15%;

b) Narrower lots (with zero side yards) reduce street servicing costs per lot and provide the homeowner with a larger back yard, if lot sizes are kept the same.[32]

Improving Acceptance of Attached Housing

Privacy can be a problem in some attached housing designs. X-A-Gon Homes[33] are designed to achieve the privacy advantages of detached housing and the efficiencies of attached housing at the same time (Figure 6), since neighbouring houses face opposite directions. Because of the requirements for streets on both sides, the planning for such housing must begin at the time of subdivision. X-A-Gon's unconvential Y-shaped properities require municipalities to change their servicing standards and lot regulations, which currently do not facilitate this type of innovation.

Also, municipalities can assist in developing positive attitudes about attached housing through improved design guidelines and location criteria. Municipal planning officials should make greater efforts to equitably distribute higner densities in and among new neighbourhoods, if other criteria such as good access to mass transit can be met.

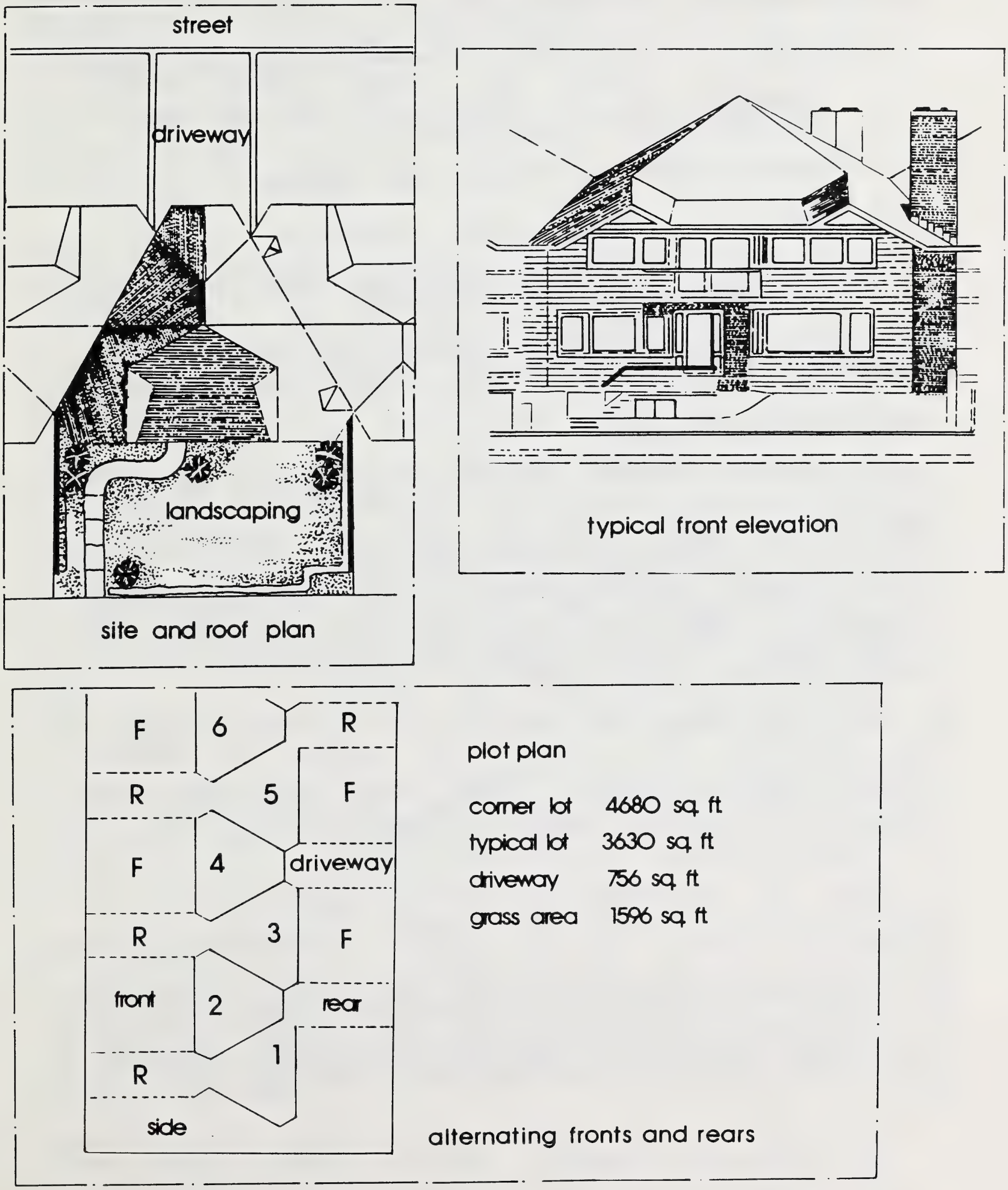
Density and Urban Form

Are assumptions about the impact of urban density on transportation energy use correct? If people live in higher density communities, close to others and their destinations, will this result in fewer auto trips, more biking, walking, and transit usage? Some studies suggest not.

> A study of the Reston New Town, for example, found many people walking - but their trips were in addition to, and not a substitute for, automobile use.[34]

Uncertainties about the relationship between density and transportation patterns does not dismiss the need for integrating transportation and land use planning in new subdivisions to achieve energy benefits. Higher density housing should be located along transportation corridors, around transit routes and stops, and near employment, commercial, institutional and recreation facilities to encourage reliance on efficient transportation modes and to minimize distances travelled.

figure 6 X-A-GON homes



corner lot	4680 sq. ft
typical lot	3630 sq. ft
driveway	756 sq. ft
grass area	1596 sq. ft

SOURCE: "THE X-A-GON HOME", (Edmonton: X-A-GON HOMES LTD., 1979) , unpublished promotional literature.

4. BUILDING AND LAND USE MIX

Introduction

Mixing land uses can save energy use by:

1) reducing travel distances between places of work, residence, shopping and leisure, thereby reducing dependence upon the automobile and encouraging use of alternate modes of transportation;
2) spreading peak loads of energy supply systems;
3) spreading peak loads of traffic on roads; and
4) increasing the potential for heating systems in buildings to use waste energy and district grids.

This section will concentrate on analyzing the potential energy savings from the first of these methods - reducing travel distances.

Land Use Mix and Urban Form

Roughly estimated, commuting Albertans in 1980 lived an average of 10 km from their place of work, and as distance to work increased, proportionately more commuters used the automobile.[35] Transportation research for Metropolitan Toronto (1971) indicated that potentially 37% of the gasoline used in communting could be saved by improving the match between place of residence and employment.[36] However, the same study also acknowledged that travel reduced in this way could only be encouraged and not regulated through land use planning.

The ideal match between home and work place is a home occupation. This phenomenon might increase with advances in business telecommunications technology. Municipalities should review their regulations to ensure that non-noxious, low traffic-generating businesses are allowed to operate from homes in as many land use districts as possible.

In Alberta, Jack Long, Calgary architect has probably been the most visible proponent of home-operated businesses. The Cottage or home businesses he foresees range from bakery, florist, professional office, restaurant, to a mail order business. A lane or loop at the end of the street would provide access, so that these businesses could not be seen from the street. Mr. Long's concept won a first prize in the 1982 Innovative Land and Housing Design Competition sponsored by the City of Calgary, the Province, HUDAC and UDI.[37]

For most commuters, job location is probably not a key factor in selecting housing - price, availability and the neighbourhood will likely be more important. Other factors limiting the match between job and home are career mobility and the number of persons in the household who are working. These limitations do not justify the development of 'unbalanced' communities where few employment opportunities are available.

Even if home and work places remain relatively mismatched, an increased residential/employment mix results in the more efficient operation of public transit service and roads, because load centres are more evenly distributed.

Land prices are a major factor in the rapid growth of bedroom communities. The author has observed that provincially funded land-banking, aimed at population decentralization and housing affordability, has supplied cheap lots in bedroom communities. This conflicts with energy conservation objectives, since in these towns, access to jobs requires long-distance travel. Government housing policies and programs leading to population decentralization should be tied closely to job development in or near these same communities. Alternately, the Province might pursue policies and programs to encourage use of more efficient travel modes such as the train, bus, van or car pools.

It is not enough to simply 'encourage' a mix of land uses in a community. Rather, it is necessary to determine what uses are complementary. When we talk of locating amenities, housing and employment opportunities closer to each other to reduce travel, we should consider the relationship among the level and pay of the jobs, the cost of housing, the type of retail outlets and amenities. These socio-economic factors were examined in the energy study conducted as part of the planning for the Missisauga City Centre complex.[38]

Physical relationships between energy (or waste) producers and consumers must also be considered to achieve better land use mix. Joint sites can be developed where housing can use waste heat produced from heavy industry or an electrical generating station, although pollution from these plants can be a deterrent.

Decentralizing Commerce

It may be more fruitful at least in the short-term, for planners to focus on reducing non - work related travel for shopping, leisure, and other local services. For example, commercial and residential land uses could be more closely integrated through policies aimed at decentralizing commerce.

Commercial strips should be discouraged in favour of convenience centres within walking distance (dispersed throughout the neighbourhood) and district shopping centres served by transit and close to high density housing.

Energy savings from decentralizing commerce can be of two types - shorter average distances travelled and a change in the modal split in favour of more efficient modes such as busing, walking and bicycling. To maximize energy savings by decentralizing commerce, transportation and land use must be carefully planned to encourage switching from the automobile to more efficient modes. Higher density housing should be located close to major commercial and recreation facilities, which should also be well served by public transit.

Local Leisure Opportunities

The preservation of landscape resources and the provision of outdoor recreation close to urban growth areas reduces the need to travel long distances to escape the urban environment. For example, in Edmonton, Beaumaris Lake in the Castledowns subdivision is a man-made facility providing year round recreation opportunities such as skating and sailing. The recreation and related energy saving benefits are a secondary benefit however, since the Lake's primary purpose is to control storm water runoff.

Building Mix

The greater the variety of activity in a building, the greater the opportunity to reduce travel. If people can meet their basic needs of shelter, work, shopping and leisure without leaving the building, then their travel needs should be minimized. However, the health and lifestyle implications make widespread adoption of this approach unlikely. More common are buildings or complexes that house two or three types of activities, such as apartment buildings with recreation facilities and some commercial uses on the lower floors.

Closely related to the strategy of mixing building and land use activities is the sharing of facilities. In public facilities, the opportunities for facility sharing are most obvious. For example, municipal recreation departments usually make every effort to utilize available community facilities, including schools and churches, prior to building their own. Red Deer's Dawe Centre is a good example of a multi-purpose community school serving a wide range of needs.

Summary

Energy savings resulting from a greater mixing of building and land use activities is probably the most difficult to accurately quantify and to justify. Because travel is (relatively) cheap, convenient, and a form of recreation for many, closer integration of land uses for shelter, work, shopping and leisure does not necessarily reduce travel even though the opportunity is provided.

Because of the difficulty in achieving a better match between job and residence locations, planning officials should first concentrate on providing local commercial and leisure facilities in new subdivisions so as to minimize non-work related travel. To maximize potential energy savings in land use planning, the strategy of a better land use mix must be integrated with other energy conservation strategies, particularly those related to density and transportation.

5. DISTRICT HEATING

Introduction

District heating systems generate heat at a central facility; the heat is then distributed to buildings for space or water heating. Energy is derived (from a boiler designed solely for the purpose) from industrial processes or from thermal power generation. When electricity and heat are produced, the process is known as co-generation. Heat, in the form of steam or hot water, is normally distributed in insulated underground pipes on a district grid.[39]

The advantages of a district heating system over individual furnaces or boilers in each building are numerous. The most important advantages,[40] are:

1) high efficiency in energy conversion;

2) possibility for using cheaper, low grade fuels;

3) possibilities for using a wide range of locally available heat sources (oil, natural gas, forestry wastes, garbage, steam turbines in power plants, industrial waste heat, and solar energy);

4) potential for conserving scarce and valuable non-renewable energy supplies:

5) flexibility as a transitional technology, since district heating can use available fossil fuels, then switch to renewable energy forms;

6) lower maintenance costs; and

7) increased feasibility for installing pollution control devices, thus improving environmental protection.

System Viability

The major factors affecting the viability of a district heating system are: energy demand, timing, scale, location and ownership as outlined in Table 7.

Table 7

FACTORS AFFECTING THE VIABILITY OF DISTRICT HEATING

PARAMETER	REQUIREMENT	POSITIVE COMMUNITY FACTORS
Energy Demand	Adequate demand in proximity to district heating plant, to minimize length/heat load ratio.	High density buildings, constructed to low energy standards.
Timing	District heating system must be available as buildings are built. This may require installation of a small portable plan initially, to minimize excess capacity and debt servicing.	Buildings built and connected to district grid over a short time period. Slower, steady construction. Facilities planned to switch from portable to permanent plant.
Scale	Large-scale plants over 1000 MW preferred due to energy efficiency and environmental protection technology. Biomass and coal systems need large areas for fuel and waste storage	Large-scale community development such as new towns. Large, low cost land area for plant and fuel storage, adjacent to urban area.
Location	Minimize transportation of fuel.	Locate systems in communities close to fuel.
Ownership	Public ownership of utility systems to facilitate implementation, due to ability to borrow money at lower rates than private sector, and institutional, long-term nature of the service.	Communities, such as Medicine Hat which have control over electrical production and distribution and natural gas distribution are more likely locations.

District heating systems may not be viable where new housing and other development is constructed to high energy standards.[41] This is because well-insulated new buildings have low space heating loads and become costly and inefficient to service with district heating systems. Therefore, the district heating strategy can be in conflict with other energy strategies which have proven viability.

Fuel Sources

Solid Waste

In Canada, approximately 0.9 t of solid waste per person is hauled to dumps annually, requiring energy for collection, compaction, transportation and landfill operations.[42] Through improved recovery and recycling efforts, much of this energy could be saved.

> Simply by better recovery and recycling from solid waste, the typical community of 100,000 could conserve up to 3.5 million gallons of fuel per year, 30,000 tons of paper and cardboard, 3,600 tons of ferrous materials, 700 tons of non-ferrous (aluminum, lead, zinc and copper) and 4,000 tons of glass.[43]

In Alberta, the province's first two municipal waste incinerators are being planned for Lacombe and Wainwright. No heat or energy recovery technology is planned for these incinerator plants because of the high extra capital cost and inadequate demand for the heat.[44] The Solid waste energy recovery technology developed to date is large-scale. This requires population levels found only in Alberta's largest cities, or regional collection systems (which incur extra energy use for the transportation of wastes to a central plant). Also, during the winter (our peak heating season), the amount of waste generated per capita is less than half that created during the summer.[45]

Gas and Coal

In Edmonton, studies undertaken between 1973 and 1978 have confirmed the technical and economic feasibility of using waste heat from the Rossdale Generating Station to heat buildings in the Downtown. However, with the declining economy and with the advent of the coal-fired Genesee Power Plant (which relegated the Rossdale Plant to a standby function), the possibility of using the Rossdale Plant for district heating then became less economically feasible. Edmonton Power has examined the potential for using the Genesee Plant for district heating, which requires heat to be transported 50 km to downtown. The study's result was the confirmation of the project's technical and economical feasibility. Edmonton Power is currently (Fall 1984) reviewing the project prior to making a recommendation to City Council and considering proposals for leasing land near the plant for greenhouse vegetable production which captures waste heat.[46]

Coal fired co-generation plants require that the coal be transported from mining sites to smaller plants in urban areas or that residential development locate near the plants to take advantage of waste heat. Both options result in transportation energy use trade-offs.

Industrial Waste Energy

In 1979, the equivalent of about 1200 MW of waste heat was available at major industrial sites in Alberta, but not used.[47] About 60% of this waste was in the form of high sulpher coke stockpiled at oil sands plants located in communities such as Fort McMurray. The possibility of using this waste for district heating purposes should be explored prior to additional subdivision development in these communities. At the Alberta Gas Ethylene Plant in Joffre, the plant's cooling water is used to heat two hectares of greenhouses, which grow tomatoes, cucumbers and flowers.

Forestry Wastes

Wood supplies are abundant in Northern Alberta communities such as Grande Prairie, Whitecourt and Slave Lake. The energy available from wood in Alberta could make a major contribution to the province's energy requirements on a continuing basis.[48] In 1979, it was estimated that there is

> sufficient wood to sustain the generation of 14,590 GWH of electricity or 106.1 X 10^6 Gj of fuel gas. This represents 73% and 25% of Alberta's demand for electricity and non-electric fuel.[49]

The circumstances needed for wood to be a viable energy source for power and heat are: the availability of large quantities of sawmill residues, a fairly large demand for both heat and power, and no other cheap fuel available. The only community close to meeting these criteria is High Level. However, demand in this town is insufficient for wood fuel district heating.

As long as fossil fuels remain relatively available and cheap, the use of wood as an energy source for district heating will be discouraged. In the long-term, however, the potential for wood as a fuel source for district heating is promising, particularly in select northern communities.

Pipelines

Waste heat is available from compressor stations located along major natural gas pipelines. For example, at the Breton Creek compressor station on the Trans Canada Natural Gas Pipeline, an average 23,150 kw of waste heat was available in 1975. Some of this could be recovered.

> Installation of a waste heat recovery unit and an electrical generator on one of the turbines at Burton Creek would make available 3,900 KW of electricity. This assumes 50% efficiency in the heat recovery unit and 60% efficiency in the steam turbine, or an overall process efficiency of 30%.[50]

This amount of energy would be sufficient to meet the heating requirements of 475 homes. Although NOVA alone has 30 compressor stations in Alberta, pipelines are not generally close to urban areas. Therefore, other uses for the waste heat, such as in vegetable greenhouses, are more realistic. For example, at the Princess compressor station in South-east Alberta, NOVA uses waste heat from the turbines to heat one hectare of greenhouses which grow tomatoes, cucumbers and flowers.

Solar Mini-Utilities

Solar mini-utilities, another form of district heating, use banks of collectors, central storage, and distribution lines to buildings. Heat is stored seasonally in large storage tanks which are efficient if buried and well insulated.

The use of active solar systems for residential district heating is not viable in Alberta at this time, nor will it likely be in the immediate future. There are too many other options available, such as passive solar systems, cheap gas, and proven construction methods for minimizing heat loads. This is not to suggest that we ignore the future possibility of solar mini-utilities since the availability of energy supplies will change over the economic life of residential areas currently being planned and developed.

Fuel Substitution and Planning Considerations

When planning new communities to help ensure the availability of long-term energy supplies, we should be examining how to ease the transition from the fossil fuel path to the soft energy path. Fossil fuel-fired district energy systems offer flexibility for the future. It is much easier and cheaper to switch a district plant to other fuels than to change the individual furnaces for compatability to the new fuel supplied.[51]

In the St. Lawrence Housing Project in Toronto, heating systems in the buildings are designed to connect to a possible future district heating grid without major conversion costs.[52] This simply involved installing a T-joint and locating plumbing to facilitate connection to the district lines.

The main thrust of this contingency planning is to minimize physical barriers when district heating systems become feasible. Another action is to set aside an area for a future district heating plant. For the potential conversion to a district heating system using active solar technology, solar access must be protected, buildings oriented correctly and roofs constructed at an optimal angle to the sun.

6. TRANSPORTATION

Introduction

Three broad strategies to reduce transportation energy use are apparent: improve efficiencies of existing modes, switch to more efficient modes, and reduce the amount of travel. Reducing personal travel is the most difficult, as it requires a lifestyle change. However, if people are still travelling the same distances to the same places, travel can be undertaken using more efficient modes without a significant lifestyle change.

Modal Efficiencies and Public Transit

Fels and Munson (Table 8) compared the overall energy efficiency of alternate transportation systems by examining: energy use in manufacturing the technology, constructing roads and lines, operations, and the average life expectancy of the technology and infrastructure. The findings show that bus and rapid rail are the most efficient modes of transportation at typical occupancy rates.

In 1980, of all Albertans commuting to work, 76% travelled by automobile, 14% by transit, and 10% walked or used some other form of travel, such as bicycle, taxi, or motorcycle. Of the people travelling by auto, 78% drove alone, 9% drove with passenger(s), 10% rode as a passenger, and 2% were involved in shared driving. Since 1976, the percentage of commuters travelling by public transit has remained about the same and the percentage of commuters involved in "car pooling" has decreased.[53]

With the heavy reliance on the automobile, the greatest energy savings can be achieved by improving the efficiency (per passenger/kilometre) of automobiles. There are reasons (other than energy use) however for promoting public transit, such as: reducing pollution, relieving congestion, and providing transportation for people without cars.[54]

Based on 1980 data, the public transit modes in Edmonton (in order of efficiency) were: diesel bus, gas bus, electric LRT, and electric trolley. Diesel bus, more than twice as efficient as electric trolley, accounted for 92% of all public transit travelled. Unfortunately diesel was the most expensive fuel per kilometre travelled. One of the reasons for the popularity of electrified travel is the relatively cheap cost of electricity.

Table 8

ENERGY EFFICIENCY OF URBAN TRANSPORTATION MODES

MODE	TOTAL ENERGY/ VEHICLE km	OPERATION ENERGY/ VEHICLE km	VEHICLE MANUFACTURE ENERGY/ VEHICLE km	GUIDEWAY MANUFACTURE ENERGY/ VEHICLE km	TOTAL ENERGY/ AVAILABLE SEAT km	ENERGY/ PASS. km FOR 'TYPICAL' OPERATING CONDITIONS
1, 620 kg Auto[a]	8.07	7.10[f]	.86	.07	1.34	5.84
900 kg Auto[a]	4.19	3.65	.47	.07	1.05	3.02
City Bus[b]	20.19	19.41	.63	.18	.50	2.45
Rapid Rail (LRT)[c]	37.18	34.69[h]	.90	1.56	.52	1.71
Personal Rapid Transit[d]	6.82	6.27[h]	.43	.09	1.14	6.30
Dial-A-Bus[e]	13.38	12.07	1.20	.11	1.34	6.69
Bicycle	.22	.09	.09	.03	.22	.22
Motorcycle	1.52	1.34	.11	.07	.76	1.36
Walk	.14	.14	--	--	.14	.14

a - With conventional internal combustion engines, 1973 averages.
b - 35-foot bus, with 40 seats, diesel engine.
c - Based on specifications of the BART system, California.
d - Six-passenger vehicle designed for Monocab's overhead monorail system, and guideway energy an average of two systems, Monocab and Transportation Technology Inc.
e - 2, 250 kg 10-passenger, modified van.
f - Energy equivalance of gasoline was taken to be 33 MJ/litre, which includes energy used in crude oil refining.
g - Energy equivalence of diesel fuel was taken to be 36 MJ/litre, including refining.
h - 30.5% efficiency for electricity generation. Also added was an amount of energy to heat and air-condition the stations.
i - Typical load factors: 1.4 persons/auto, 20% occupancy for bus, 30% for rail, 1.1 passengers (i.e. 20% occupancy)/PRT vehicle, 20%/Dial-A-Bus, and 1.1 persons/motorbike.

After: Margaret Fulton Fels and Michael J. Munson, "Energy Thrift in Uhban Transportation: Options for the Future", The Energy Conservation Papers ed., Robert H. Williams, (Ballinger Publishing Co.: Cambridge, Mass., 1975), p. 13.

Public transportation routes and terminals should be planned to provide good access from high density areas (Figure 7). In addition, major recreation facilities should have good transportation access, especially during peak demand times. In new subdivisions, transit routes should travel through the middle of the community, not around the edge. This has direct implications for road network and subdivision planning, as shown in Figure 8.

It is important to encourage higher density land uses around major bus terminals and LRT stations and to plan for convenient intermodal links, such as 'kiss and ride' drop-off areas, parking, and convenient, sheltered bus stops.

Street and Parking Facilities

Through careful lot layout and design, roadway lengths can be reduced about 10% to 12% (Figure 9). The use of clustered house designs can reduce road lengths by about 25%, compared to conventional layouts (Figure 10). Road systems, planned on a hierarchy of access needs, eliminate excess stopping and starting, idling and turning, and decrease total travel time.[55]

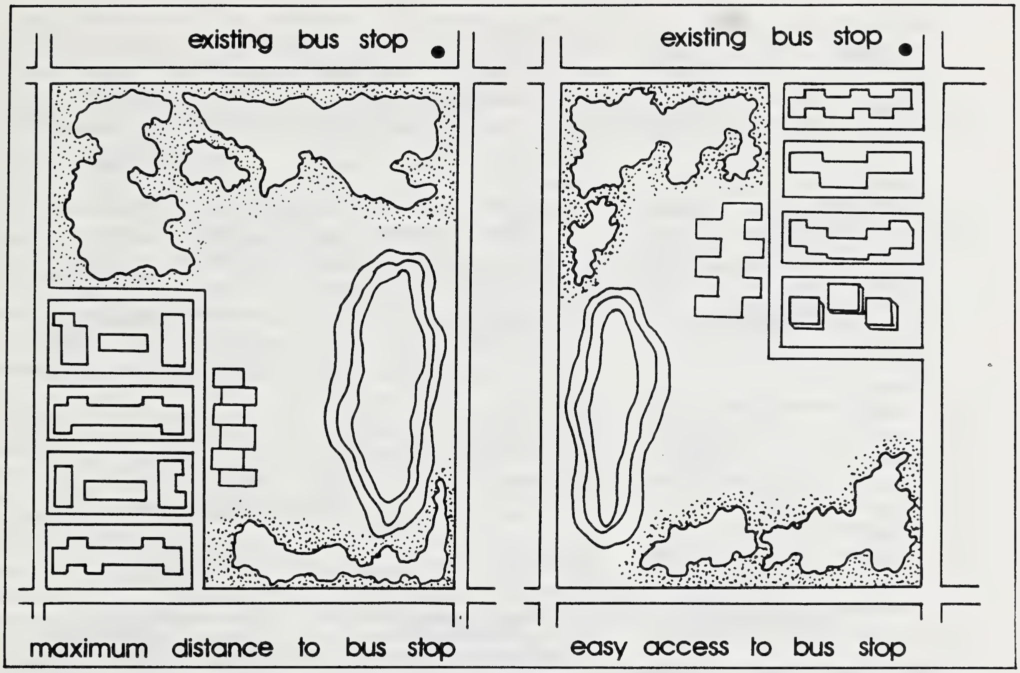
Ross Guffei, an Edmonton planner, claims the amount of land dedicated to roads in a subdivision can be reduced from 30% to 18%. Under an Alberta Housing and Public Works Research Grant, Guffei developed the "Enhanced Flag Lot Concept" for Tritek Engineering Ltd.

> In the Enhanced Flag Lot Concept, two-thirds of the houses in the subdivision front on to roads. The remaining one-third are tucked behind the front set of conventional lots in what amounts to the back half of the property. A long private driveway runs from the road alongside of the front property to the interior lots. Back lanes are eliminated.[56]

In certain cases, narrower streets can fit with the solar access strategy. The wider spacing in parts of a subdivision, required to ensure solar access, could be provided by land left over from narrow streets. However, this depends upon local standards for street widths, set backs, and lot depths.

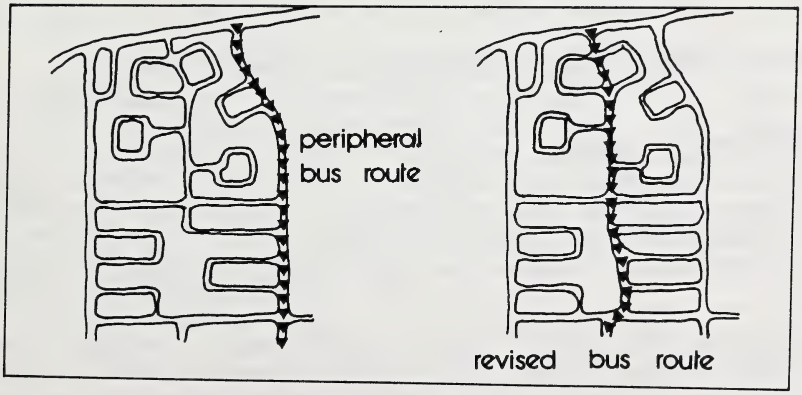
Back lanes are used for garbage pick-up and access to rear garages and could be considered a space waster. The elimination of lanes creates a problem, since utilities are usually buried there. In some newer subdivisions, rear alleys have been replaced by pedestrian/bike trails and common open space, providing a convenient utilities right-of-way.

figure 7 siting buildings for improved public transit access



SOURCE: A.S. Kennedy and J.F. Tschanz, Factors That Influence The Acceptance of Integrated Community Energy Systems (Argonne National Laboratory: Argonne, Illinois, 1978).

figure 8 street and bus route planning



SOURCE: Thompson, Berwick, Pratt & Partners et al., Physical Plan Tumbler Ridge (B.C. Ministry of Municipal Affairs and Housing: Victoria, 1978).

figure 9 subdivision design and street length
density of 44-46 units/ 10 acres is constant

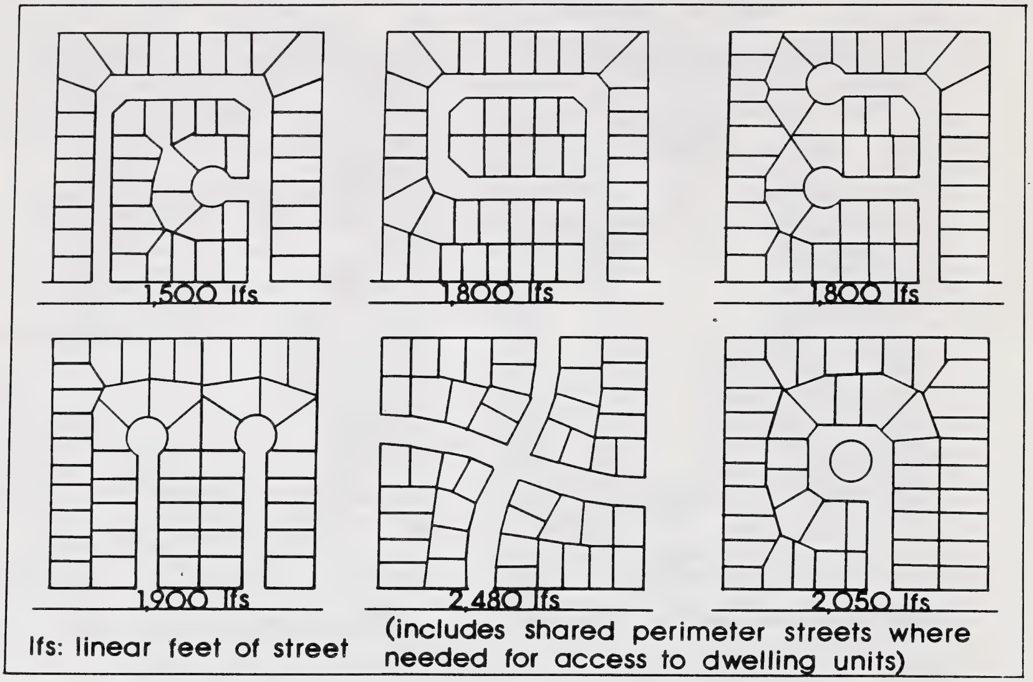
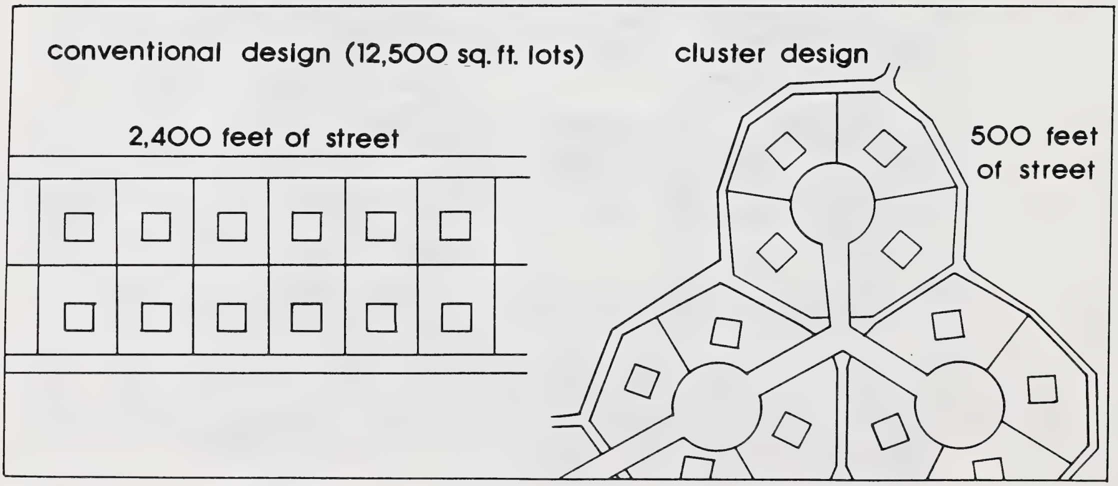

1,500 lfs
1,800 lfs
1,800 lfs
1,900 lfs
2,480 lfs
2,050 lfs
lfs: linear feet of street
(includes shared perimeter streets where needed for access to dwelling units)

figure 10 clustered housing and street design



SOURCE: A.S. Kennedy and J.F. Tschanz, Factors That Influence The Acceptance Of Integrated Community Energy Systems (Argonne National Laboratory: Argonne, Illinois, 1978). (Fig. 10&11)

Municipalities can reduce the energy used for street and outdoor lighting by using sodium systems. This can reduce power needs by more than 50% and improve illumination levels. Savings on electricity and maintenance/replacement costs must be weighed against installation costs, particularly where serviceable units are to be replaced.

When deciding on energy efficient lighting systems, municipalities have several options from which to choose - they can adopt a policy and program of converting sections of the existing system or replace old lamps as they fail (with more efficient units). Factors which need to be considered include the type of existing lighting and the location and condition of poles and brackets. From case studies in Ontario, the following was concluded:

> All new street lighting installations should use the most efficient light source available (i.e. either low or high pressure sodium) to meet requirements.
>
> Municipalities with incandescent street lighting should consider converting their system to high pressure sodium units immediately.
>
> Where the existng systsm is mainly fluorescent, municipalities should examine carefully the present and future cost effectiveness of converting to a spot replacement with a sodium lighting system.[57]

Parking

Another strategy for saving energy is to reduce the size of new parking facilities and to make more efficient use of existing facilities. In a Davis, California subdivision, all on-street parking is eliminated in favour of off-street visitor parking areas shared by clusters of homes.[58] Shared parking among complementary land uses can also apply to daytime shopping and employment and evening recreation. Attention should also be given to improving the design of parking facilities to minimize congestion and the energy used to find a parking stall and exit.

Reducing the amount of land used for roads, alleys and parking lots has numerous energy spin-off benefits: lower energy costs for construction and maintenance, higher overall density and reduced run-off and storm sewer requirements. Also reduced are requirements for street lighting, sidewalks, and service lines for gas, water and power, sanitary sewers, telephones, and cable television.

Pedestrians

Walking is the most efficient mode of travel in addition to having health and environmental benefits. Table 9 provides a checklist of pedestrian design guidelines and their relation to meeting the objectives listed in the Table.

When planning for pedestrians, it is important to remember that walking is necessary to link all transportation modes. For example, pedestrian routes should follow the most direct paths to bus stops and other destinations which not only encourages walking, but encourages transit use.

Table 9

PEDESTRIAN PLANNING AND DESIGN

Objectives: 1 Safety 2 Security
3 Convenience 4 Continuity
5 Comfort 6 Coherence
7 Attractiveness

DESIGN GUIDELINES	OBJECTIVES 1	2	3	4	5	6	7
1. Distinctive crosswalk delineation	x						
2. Adequate lighting, especially at crosswalks	x	x					x
3. Traffic signals timed for pedestrians, not cars	x		x				
4. Pedestrian connectors bisecting long blocks			x				
5. Well designed and located street furniture	x						x
6. Temporary or permanent pedestrian malls	x	x	x	x	x	x	x
7. Underpass or Overpass across streets	x						
8. Buildings & route siting & design for clear views of pedestrians		x					
9. Covered arcades					x		x
10. Ramped curb cuts for wheelchairs, baby carriages, roller skates, deliveries, shopping carts bicycles and elderly	x		x				
11. Pedestrian networks linking attractions & buildings above or below grade	x		x	x	x		
12. Clear Directional signing						x	
13. Landscaping (of the non-concealing type)		x		x	x		x
14. Building siting for solar access and abutting wall reflectivity to increase warmth & melt snow					x		
15. Return ducts in district heating systems located to melt snow					x		
16. Pavement colour and texturing				x			x
17. Outdoor art (eg. murals on exterior walls)							x
18. Outdoor gathering places for special events							x
19. Preservation of views						x	x
20. Pedestrian plazas built at grade to sidewalk				x			x
21. Pedestrian route cuts through berms			x				
22. Attention to snow accumulation and clearing			x	x			

After: John J. Fruin, Pedestrian Planning and Design (Metropolitan Association of Urban Designers and Environmental Planners, Inc.: New York, 1971).

Bicycles

For comprehensive bike facility planning, trips should be classified in three categories: commuter, shopping, and recreational. There are three classes of bike routes, as shown in Table 10.

Table 10

CLASSES OF BIKEWAYS

TYPE	DESCRIPTION	BEST LOCATIONS/USE
Class I	- Exclusive bicycle use. - Separated from autos & pedestrians. - Crossing autos & pedestrians minimized, two-way directional.	- Open spaces, parks. - Road & rail rights-of-way. - River and canal banks. - Primarily recreation oriented.
Class II	- Exclusive bicycle use. - Adjacent to, but separated from autos & pedestrians by physical barriers or painted markings. - One-way directional. - Should be above curb when adjacent to heavily travelled or high speed roads.	- On both sides of 2-way street or on right side of 1-way street, when width adequate. - Primarily commuter oriented.
Class III	- Signs designate road or sidewalk as bikeway. - Least expensive, but least safe for autos, bikes & pedestrians. a) Shared right-of-way with autos. b) Shared with pedestrians (safer than sharing with autos).	- Existing lightly used streets and sidewalks. - Temporary, if width, shoulder traffic volume and speed allow. - Temporary, if width adequate.

After: Bruce L. Balshone et al., Bicycle Transit - Its Planning and Design (Praeger Publishers: New York, 1975), pp. 34-37.

Extra attention must be given to Class III - Shared Corridor - bike routes (the most common in Alberta), to ensure safety and enjoyment for the bicyclist.

Minimum standards for bikeways need to be adopted for factors such as width, vertical clearance, and radius of curves and grades.[59] Other design considerations include: intersections to facilitate safe crossing and turning, curb cuts, bike storage facilities, lighting, landscaping, grade separations, visibility and street markings, signage, system continuity, and the minimization of stops.[60]

Interestingly, snow can benefit bike route planning. In Montreal, planners found that the extra width of streets for snow clearance is suitable for summertime bike paths.[61]

The most important aspect of bikeway planning is for safe crossings and travel through intersections, since intersections are the most dangerous areas along bikeways. Key considerations are warning signs and areas for bicyclists to wait safely for signal changes.[62]

In the Unites States, significant numbers of commuters are bicycling to transit stations, partly because park and ride facilities have reached maximum capacity. Design suggestions for bikes at transit stations are:[63]

1) erect bike approach route signs;

2) locate storage facilities in high traffic areas close to the station or in view of station staff;

3) convert some auto parking spaces to bike storage, if ridership is high; and

4) make bike storage service available free.

Intermodality for Inter-City and Intra-City Travel

Important relationships exist between intra-city (car, bus, cab) and inter-city (bus, train, plane) modes of transport. For inter-city travel, generally the airplane is suited to long-distance, the train is best for medium distance, and the bus is suited for short trips. Integrated transportation centres are needed where all services link so travellers can move easily from a plane to an inner-city train or bus, or from a suburban commuter train to a local bus or city LRT train.[64]

7. TRADE OFFS

Resolving Trade-Offs Between Energy Conservation Strategies

Energy conservation strategies (where the net energy effect would be minimal or negative) can be avoided if there is an awareness of potential trade-offs. To resolve conflicts among design criteria, sophisticated data management techniques are useful to illustrate both qualitative and quantitative costs and benefits. Modelling or simulation techniques using computerized data processing, would likely be necessary for complex energy analyses. This allows the designer to accurately compare the net energy effects of various combinations of land use mixes, densities, and transportation options. For example, the multi-purpose nature of wind control and the protection of solar access suggests the need for modelling techniques to assess alternatives during planning and design. Simple technology has been developed to simulate a building's daily and seasonal shading patterns. Technology to simulate the effects of wind on a structure, and vice-versa, has also been developed. These can be illustrated with or without the aid of a computer.

The simulation of all major energy variables for a development would tremendously aid:

1) resolving real or potential conflicts;

2) designing the most efficient future developments possible;

3) quantifying the costs and benefits of all options; and

4) selecting the most feasible option, based on the above.

Modelling exercises conducted as part of the Guelph subdivision design study cited earlier, simulated: density, housing mix, house type, solar orientation, and development costs. The modelling also considered the effects of windbreaks on building heat loads. From the author's literature review, this was the most sophisticated simulation study on energy efficient subdivision design options.

Currently, some Alberta developers are beginning to use modelling to achieve innovative design. However, the analysis tends to be limited to those benefits that contribute directly to their business objectives. A major deterrent to the developer is the cost of conducting a comprehensive evaluation of subdivision design options. Presently, the most that can be expected are incremental changes geared toward specific energy use improvements. This suggests a role for government in developing and testing a comprehensive system for evaluating subdivision design options, since many users could benefit, and the taxpayers who bear the costs would ultimately benefit.

When assessing land use and design options, energy conservation is only one of the evaluation criteria which must be considered. When energy strategies conflict, such as siting buildings for wind protection versus solar gain, the introduction of other quantitative criteria such as cost, and qualitative criteria such as aesthetics, can help resolve the problem. In this manner, energy conservation concerns are integrated into the land use planning and design process instead of being treated as a single-purpose issue.

8. MUNICIPAL ROLE

Developing a General Municipal Role

The greatest number of implementation measures to directly or indirectly reduce energy in land use fall under the jurisdiction of the municipality. There are three reasons a municipality should play a leading role: 1) the municipality can save on energy costs in its own buildings and operations (which can then be passed on to taxpayers); 2) planning decisions that take energy into consideration can reinforce other municipal objectives (such as provision of affordable housing and environmental protection); and 3) developing a higher level of local self-reliance is insurance for the future, when we will likely experience energy shortages.

Municipalities need to initially address three general issues in developing strategies and implementation programs for energy conservation. They are: 1) choosing between incrementalism versus comprehensiveness, 2) internal versus community-oriented approaches, and 3) mandatory regulations versus voluntary guidelines.[65] By examining these, the scope of a municipal program and its starting point become apparent.

Many California communities which pioneered energy programs favored beginning with limited measures (incrementalism) and progressed gradually to broader measures (comprehensiveness). If progams are simply transplanted from one community to another, there is the hazard of by-passing the valuable learning process, particularly where changes in attitudes and behaviours toward energy consumption are involved.[66] The key seems to be learning from the experience of others by carefully adapting programs to local conditions.

Another major decision in developing municipal strategies and implementation programs is whether to focus inwardly on the municipalities' own buildings and operations, outwardly to the community, or both. There are four reasons for concentrating initially on in-house measures: 1) major cost-saving opportunities, with no or minor investment, are available and are not politically risky; 2) the municipality can effect changes swiftly with immediate results; 3) the municipality can set an example by first getting its own house in order; and, 4) municipal officials can gain valuable experience in their own operations before turning their attention to broader community energy problems.

Should municipalities adopt a mandatory approach where the community is compelled to save energy? Or, should energy conservation be voluntary, where the municipality merely facilitates energy conserving public actions? Given the inadequacies of Alberta's enabling legislation, the legal authority to adopt a mandatory approach is questionable. Voluntary or incentive programs provide positive reinforcment, usually in the form of money savings, by using tools such as zoning and budgeting.[67] The major advantage of the voluntary approach is a political one, particularly in communities where minimum government intervention and high levels of personal freedom are valued. The disadvantage to the voluntary approach is that the major energy savings actions, which require individual and collective behavioral changes, continue to be avoided.[68]

Municipal regulations have, so far, concentrated on minimizing barriers within land use regulations (the voluntary approach).[69] This approach entails removing institutional barriers to permit the market, based on economic signals, to allocate resources efficiently.

> In general, we shy away from mandatory programs because there is backlash and also because, in most cases, we prefer the workings of the market while providing incentive and opportunity for people to do what's in their own best interest, removing institutional barriers so that they aren't blocked from doing what the economic signals indicate to them is in their own best interest, and then simply letting the market allocate it.[70]

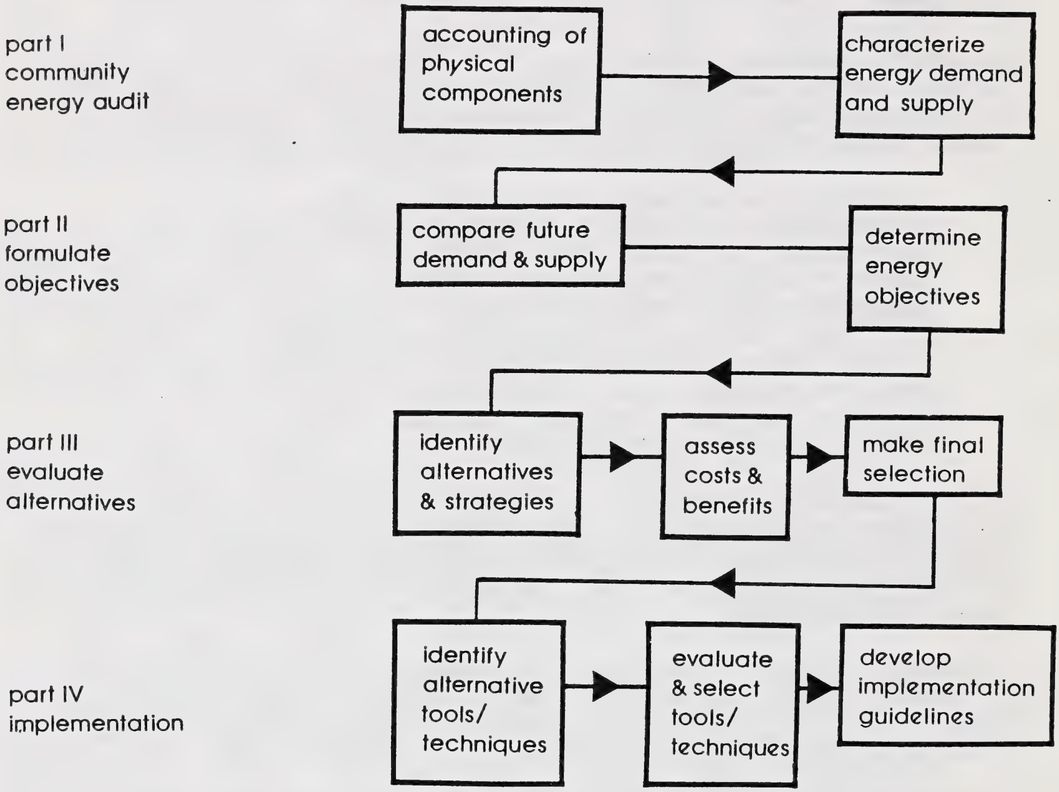
Before adopting strategies and implementing policy instruments proven effective elsewhere, careful consideration must first be given to differences in local energy problems, development traits, enabling legislation, municipal government operation, and public support and attitudes.[71]

A proposed process for comprehensive community energy planning, from energy auditing to developing implementation guidelines, is shown in Figure 11. The planning of energy efficient new residential subdivisions would be just one component of energy planning.

Community energy audits, the first step in comprehensive community energy planning, provide a description of energy use and help in the development of energy strategies and policies responsive to local conditions. Overall consumption and peak demand for each fuel type, end use, and activity sector, over a five to ten year period, are basic data requirements for the audit. There are six reasons why energy audits are useful:

1) to establish realistic conservation targets and demonstrate savings;
2) to accurately project future energy demands;
3) to help assess the viability of alternative technology;
4) to help identify and measure impact of provincial and national policies;

figure 11 comprehensive community energy planning methodology


part I
community
energy audit
accounting of physical components
characterize energy demand and supply
part II
formulate
objectives
compare future demand & supply
determine energy objectives
part III
evaluate
alternatives
identify alternatives & strategies
assess costs & benefits
make final selection
part IV
implementation
identify alternative tools/ techniques
evaluate & select tools/ techniques
develop implementation guidelines

Source: Hittman Associates Inc., Comprehensive Community Energy Planning, Vol. 1 (of two Volumes), A Workbook (U.S. Department of Energy: Washington, D.C., 1978), p.5.

Author's note: The basic structure of this figure is derived from the above reference; some of the wording has been changed however without altering the meaning.

5) to help develop energy impact statements; and
6) to provide input into developing relevant energy policies.[72]

In the absence of local audits, provincial energy use profiles are useful approximations of a community's energy use patterns. Provincial figures can be adjusted to reflect local conditions.

Municipal Planning Tools

Introduction

The Planning Act, 1980, was reviewed to identify planning tools available at the local level for achieving energy conservation objectives through land use planning.

It appears that most of the energy efficient design options previously outlined can be implemented without creating new regulatory devices or policy instruments because existing policy instruments are numerous and relatively easy to modify.

The remainder of this chapter is devoted to describing 15 municipal planning or policy instruments for implementing energy efficient subdivisions. These policy instruments are:

Statutory Plans and Bylaws	- Regional Plan - General Municipal Plan (GMP) - Land Use Bylaw (LUB) - Area Structure Plan - Area Redevelopment Plan - Subdivision Plan - Replotting Scheme
Flexible Negotiating Tools	- Annexation - Planned Unit Development - Development Agreement - Site Plan Review - Innovative Residential Development Area
Construction/Financing	- Capital Improvement Plans - Direct Financing
Education Programs	- Various

New policy instruments such as energy impact statements or new types of zoning are not discussed since these would likely require major ammendments to provincial legislation. Due to space limitations, municipal taxation and pricing policies, which could have some impact, are also not addressed.

Regional Plan

In providing policy direction to local plans on land use, energy use could be considered separately or as a part of established parts of a regional plan, such as: the physical environment, natural resources, existing land use, or population growth. Energy conservation could be interpreted to be part of the Planning Act's statement on the 'economical and beneficial development and use of land'.

The primary role of a regional plan with respect to energy conservation in land development is to promote an energy efficient settlement pattern, characterized by a compact form and higher densities. Regional plans should also promote a mix of land uses to integrate all activity functions and regional approaches to efficient land infrastructure, especially transportation facilities. These in turn, could affect the location of a subdivision, its servicing, mix, and density.

While the regional plan could be an important policy instrument for implementing energy conservation, it generally lacks the power and specificity to have a major impact at the local level.

General Plan

Energy policy statements in the general municipal plan would serve two important roles; to demonstrate municipal commitment to energy conservation and provide the framework for developing and implementing specific programs and tools (such as zoning bylaws).[73]

In September, 1981, Edmonton City Council passed a bylaw amending the General Municipal Plan -

> to promote energy efficient design and opportunities for energy conservation in land use and transportation planning, municipal servicing and building design.[74]

The bylaw outlines a wide range of energy related planning objectives and policies which address: land use pattern and density, transportation, lot and building orientation, landscaping, servicing design standards, district heating, building design, and the promotion of energy conservation in the overall community.

In certain policy statements in the bylaw, such as the one relating to "Leadership in Energy Conservation", the report provides a checklist of possibilities and specifies that actions will be decided in the future. This checklist is provided in Table 11. For a general plan, this is the right approach - to be general in nature. In short, the general plan should contain only broad policy

Table 11

ENERGY CONSERVATION PROGRAMS

	CIVIC ADMINISTRATION PROGRAMS	COMMUNITY PROGRAMS
Building Related	Energy Audits Monitoring Programs Weatherization & Retrofits Performance Standards Performance Targets Solar Technology Department Incentives	Energy Audits Mandatory Weatherization Retrofits (cost-effective) Performance Standards Solar Technology Design Competitions Building Code Costing
Acquisition	Life Cycle Costing	Life Cycle Costing
Special	Demonstration Projects District Heating Recycling Energy Research	Demonstration Projects Energy Efficient House Recycling Business Communications
Transportation	Street Lighting Transit Improvements Pedestrian/Cycling Facilities Parking Policy Changes	Small Automobiles Car/Van Pooling Walk/Cycle to Work Transit Promotion
Education	Employee Training Staff Seminars Feedback on Energy Use Conferences Employee Accountability	Public Information Public Involvement Target Group Consultation "Conserver Ethic" Energy Conservation Week
Planning & Land Use	Development Standards Building Orientation Protecting Solar Access Landscaping Encouraging Energy Conserving Plans	Landscaping Home Conserver Program Energy Conscious Statutory Plans Home Business Operations
Data Base	Municipal Energy Profile	Household Energy Profile

Source: "Appendix B - Policy Report #16 General Municipal Plan Volume II" (Edmonton: City of Edmonton Planning Department, 1981), Chart 19.1, p. 6.

statements and avoid dealing with the implementation. Due to other priorities unfortunately, the Planning Department for the City of Edmonton has made little progress in implementing this Energy Conservation bylaw amendment.

Land Use Bylaw

To avoid potential conflicts, general statements in the GMP should precede changes to the land use bylaw. The land use bylaw regulates many factors which have direct or indirect energy use implications. These regulations can be ammended to facilitate efficient design. The land use bylaw can encourage energy efficiency in many ways, including higher densities and integrating land use activities. By regulating the height, location, spacing, and external design of buildings, land use bylaws can also facilitate the use of alternate energy systems.

In direct control districts, energy conservation elements could be considered as 'merits' in proposed developments, and appropriate incentives offered to encourage such action.

The land use bylaw should provide greater integration among industrial, residential, and commercial areas to minimize travel. The specific zoning and permitted uses should be selected in consultation with the developer to respond more accurately to market realities and the projected socio-economic community profile.

Zones for neighbourhood commercial facilities, such as grocery stores and recycling centres, should be close to high density areas and centrally located to serve a maximum number of people. The operation of home businesses can be encouraged by allowing them in more residential districts and relaxing the restrictions for the types of businesses permitted.

Opportunities for using waste resouces could be improved by the appropriate use of the land use bylaw. For example, industrial waste energy can be used for heating greenhouses or buildings, but zoning changes would likely be needed to permit the location of district heating technologies in residential neighbourhoods.

The land use bylaw is the primary instrument for achieving higher densities. Subject to market acceptablility, planners can help eliminate barriers and promote higher density development by ensuring that zoning standards are felxible enough to reflect changing market conditions and helping streamline approvals.

In Canada, "solar zoning" through the land use bylaw will likely become the main tool to protect solar access particularly in new areas. In this regard, the land use by-law could control: lot shape, building set-back, height, vegetation placement and orientation on the lot.

In Alberta's northerly location, a relatively long north/south spacing distance is required between buildings to minimize shading. Therefore, the long axis of most lots should be north/south. Shading can be minimized by designing relatively uniform building heights and designing buildings so that the roofs peak as far south as possible.[75] Wide and shallow lots are suitable for bungalows or for higher buildings which have open space to the north.

As illustrated in Figure 3, the use of unconventional lot shapes is needed in certain situations to facilitate solar access. Set-back standards must then be revised to maintain adequate spacing between buildings.

> Homes on the north side of east/west streets would have an exact front yard set-back specified in the by-laws, while north entry homes would be required to have uniform rear yard set-backs.[76]

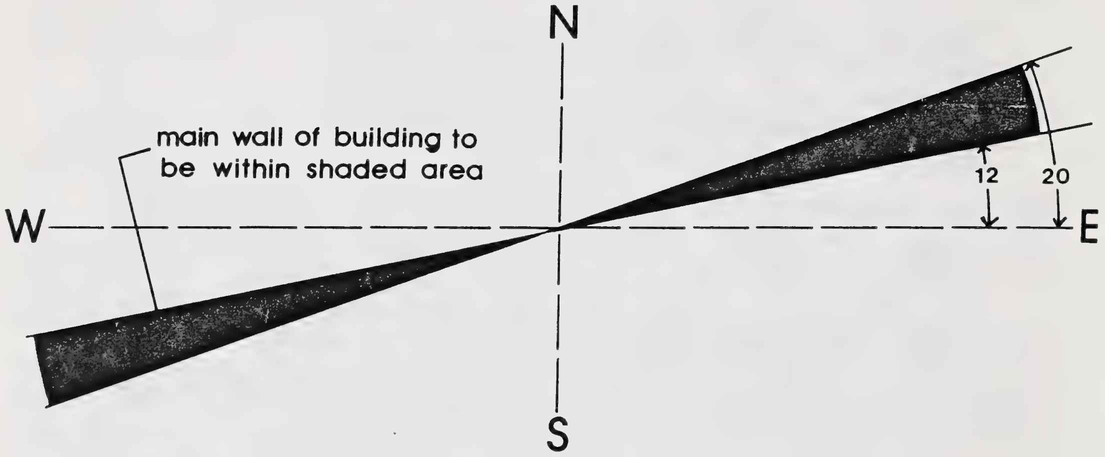
Buildings located on the north part of the lot give the owner control over the largest area to the south, thereby eliminating obstructions.

On north/south streets with lots aligned east-to-west, houses can be built with a solar orientation if the set-back requirements allow flexibility in house placement. This requires houses to be placed diagonally on the edges of lots and in an alternating, off-set pattern as illustrated earlier in Figure 2.

Zoning, which considers house orientation and mix, can optimize solar gain in new subdivisions. As shown in Figure 1, some house types are better suited to north side locations on east-west streets and some house types are more suited to north-south streets.

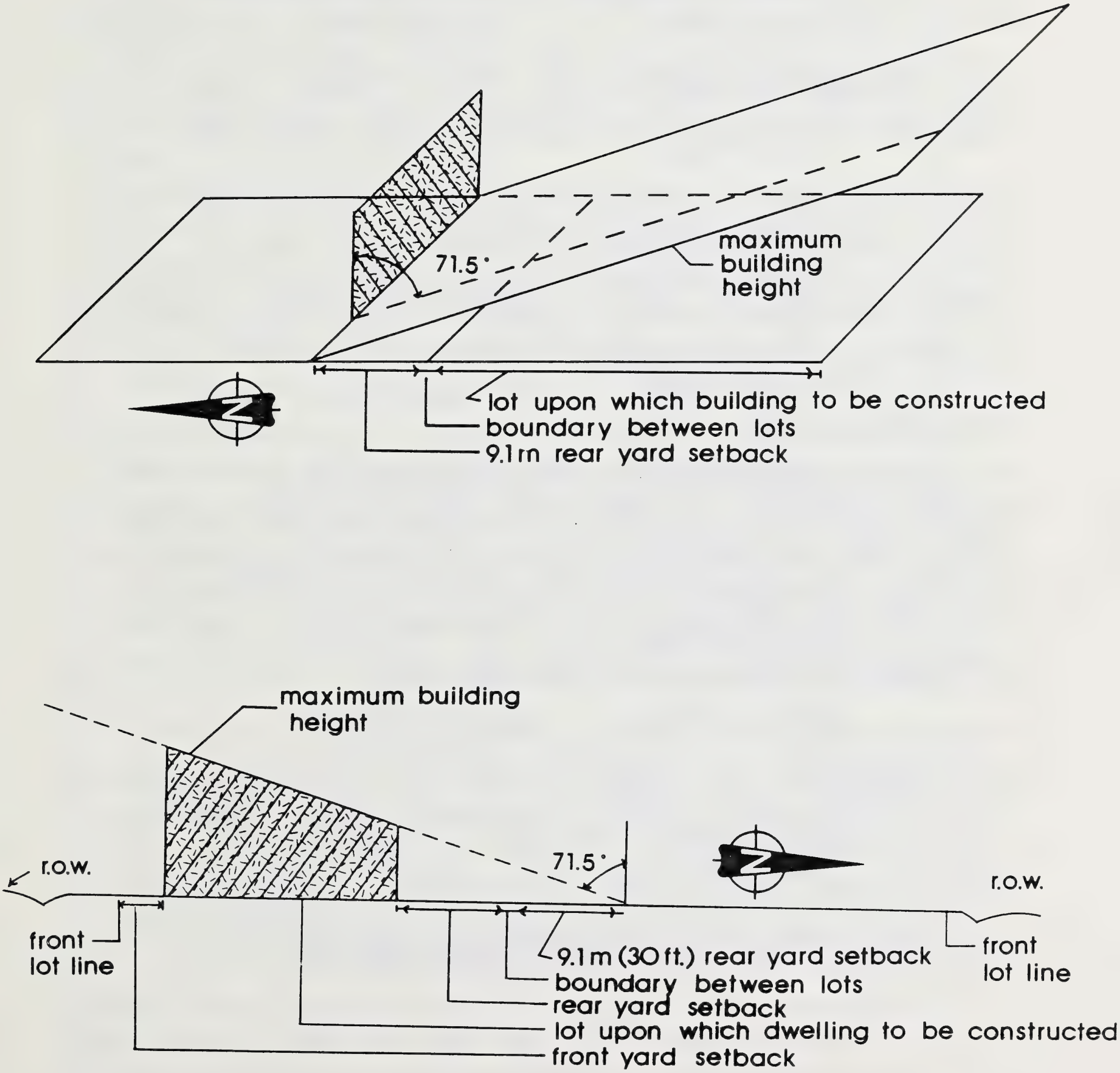
Finally, the LUB could incorporate vegetation species and placement. This would help minimize the shading of critical areas on neighbouring properties. Also the role of vegetation for wind protection should be considered.

In 1979, the City of Brampton passed a Solar Zoning Bylaw. It is based on two principles. First, all houses must have the main wall oriented 12° to 20° east of south (see Figure 12), but this still allows some flexibility for house location. Second, the by-law uses sloping plain (or envelope) zoning - the closer the house is to the south lot line, the higher the house can be (see Figure 13). Keeping the highest point of the roof to the south allows figure 12 brampton's regulation of the direction of south facing walls



SOURCE: Ross, Greg, "Energy Conservation in Land Use Planning" (City of Brampton, Ontario: Brampton, 1979), p.2.

figure 13 maintaining solar access by zoning controls



SOURCE: Greg Ross, "By-Law 139-79", (The City of Brampton: Brampton, Ontario, 1979).

houses to be placed closer together thereby preserving density. Finally, the sloping height limit encourages a roof shape at an optimum angle (normally, latitude plus 15°) for the possible addition of active solar systems.[77] It should be noted that the bylaw was designed for a relatively flat site, and might need to be modified for sloping sites.

Even though solar technology is not widely accepted by the public and not feasible for many developers, zoning is useful to protect solar access for add-on solar technology. A bylaw can also protect areas for district heating plants and transmission right of-ways.

Another application of land use bylaws is for parking requirements. Parking facilities do not usually contain an adequate supply of smaller stalls for compact vehicles (although this is changing). If stall sizes could be reduced by 25% from the norm, then it might be possible to reduce the price of parking a small vehicle by 25%, offering an incentive to drive a small car. Stall standards should be reviewed and revised regularly to account for the proportion of smaller vehicles in the community.

Area Structure Plans

The area structure plan provides the link between the general plan and detailed planning. Any general plan policies relating to energy conservation and land use should be reflected in area structure plans. There are four main elements related to energy use within the scope of an area structure plan: sequence of development, land uses, population density, and transportation routes and utilities. The degree to which energy use is addressed at this stage of community planning will affect which energy conservation objectives can be achieved at the subdivision and site levels.

The South March Energy Conserving Community, planned in the Ottawa area, illustrates the opportunities for conserving energy in the area structure plan (see Tables 12 and 13). As indicated, the area structure plan should include an assessment of the locational attributes and the energy ramifications of the subject lands. The locational analysis can be sensitive to: the energy implications of site servicing, loss of farmland, shape and size of the development, and relationship to the greater urban area. The conceptual design of the development can lay the groundwork for energy-related factors such as density, land use mix, energy systems, and street networks.

Table 12

ENERGY CONSERVATION FEATURES OF THE SOUTH MARCH COMMUNITY

TOPIC	CHARACTERISTICS	ENERGY FEATURES
Size	178 ha, 6000-8000 people	Suffient for schools, shopping, local services
Shape	Generally Square	Compact land use
Ownership	Primarily under 1 owner	Offers control in implementing concepts
Soil type	Thin till & thick clay	Low agricultural use
Topography	Rolling, west to east general slope	Natural drainage to Ottawa River
Vegetation	Portion of site cleared, woodlot on remainder	Harvest fuel from woodlot, build on remainder
Hydro Easement	Traverses entire site	Park/Pedestrian system
Schools	Public school within 1.6 km	Utilize during initial development period
Roads	Facilities to be soon constructed will result in excess capacity	No new or expanded routes required
Public transit	Close to planned future transit service routes	Allows load balancing on route serving nearby industrial area
Sanitary Sewer	Pumping station & trunk sewer have excess capacity Line only 610 m away	Minimal capital & expenditures for sewage
Water Supply	Main line 1220 m away	Minimal water costs
Employment	In adjacent industrial park	Minimized travel

After: M.M. Dillon Ltd., Part A - South March Energy Conserving Community. October, 1977.

Table 13

ENERGY CONSERVATION FEATURES OF THE SOUTH MARCH CONCEPT PLAN

TOPIC	CHARACTERISTICS	ENERGY FEATURES
Energy System	District grid for hot water & space heating	Reduced capital costs Adapts to many fuels Co-generation option
Local Services	Central commercial spine Mixed land uses - commerce, housing, schools, etc...	Potential for travel reduction & facility sharing
Density	25-37 units/ha is about twice current standards	Compact community Attached, efficient units
Housing Design	Higher standards & design for passive solar gain	Reduced heating demand
Block Shape & Size	Large blocks of 213 m X 107 m, housing on edges	Open space between rows of units minimizes shadowing effects
Open Space	Woodlot & recreation on 1/2 of site, land normally built with sprawl	Wood as energy souce Close-by park to reduce travel Compact urban form
Street System	Grid, connected to Main St. No cul-de-sacs or dead ends	Buildings face south Efficient street maintenance & protective services by Town
Landscaping of Open Space in Housing Blocks	Conifers on southern part Diciduous on north part	Winter wind protection Winter sun penetrates south-facing windows Excess wood harvested Pleasant park provided

After: John Hix, Part B South March Energy Conserving Community, October, 1977.

Area Redevelopment Plans

The opportunities for introducing energy concerns are similiar to those for area structure plans, with one difference - a redevelopment levy may be imposed on development. This levy could establish community amenities such as school and leisure facilities or upgrade a substandard facility. Area redevelopment plans could be prepared for low density areas that have potential for higher density. This could be a means to increase the self-sufficiency of these areas and reduce travel requirements.

Subdivision Plans

The Subdivision Regulations in the Planning Act restrict the general location of subdivisions. For example, Country Residential subdivisions cannot be located close to urban areas, and subdivisions in the vicinity of highways are subject to restrictions regarding location, access, lot frontage, and lot sizes.

The subdivision approving authority, when reviewing a subdivision application, must currently consider factors such as: topography, soil, storm water, flooding and erosion potential, access to roads, water, sewage, solid waste, and adjacent land uses. Energy conservation objectives could be included in this review. Climatic factors such as: aspect, wind conditions, precipitation, sun, and shade which are not specified in the Planning Act, could be added to make the subdivision review more comprehensive.

In local subdivision plans, other opportunities to implement energy conservation strategies are in the area of: standards for circulation, open space requirements, lot shape, housing mix/location, provision of public utilities, and designing in harmony with the sun, wind, and vegetation.

In subdivisions with densities between 30 and 54 dwelling uits per net hectare, an additional 3% of land may be taken for reserve. For densities greater than 54 units per net hectare, an additional 5% may be taken. Some developers may be discouraged from higher density developments if municipalities adhere to this. The lower density alternative gives the developer 2% more land to market thereby increasing the subdivision's feasibility. Public reserve requirements should be on a sliding scale, varying proportionately with density. That is, a fixed amount of park reserve per capita should be required in all subdivisions, and municipalities should encourage the provincial government to change the Planning Act to reflect this.

In proposed subdivision plans, the preference for east/west streets should be flexible to adapt to topography, integrate with future or existing streets outside the development, and preserve natural features. [78]

Although current width standards vary for streets by type and projected traffic volume, these standards may still be excessive.

> While 36 ft. is a common width throughout the country for collector and sub-collector streets, width could be reduced to 26 ft. and still provide excellent performance. Widths for lightly used cul-de-sacs could be reduced to 18 ft. or even 16 ft. under certain conditions. [79]

New standards for subdivisions usually restrict parking and provide a sidewalk on only one side of the street. The lack of a sidewalk may not significantly detract from pedestrian needs if rear walkways are provided.

Another way to achieve energy efficiency in new subdivisions is to use restrictive covenants. Restrictive convenants established by the developer may, however result in trade-offs between efficiency and aesthetics when the subdivision is approved. Possible convenants relevant to energy include: those restricting the use of solar collectors, roof structures, greenhouses, vegetable gardens and clothes lines. By negotiating conditions favourable to energy conservation in the subdivision approval process, these potential obstacles can be minimized. [80].

Replotting Schemes

Replotting schemes are undertaken to restructure an existing subdivision into a different subdivision pattern. The growth of communities into rural areas previously subdivided for low density use, is one application of replotting schemes. Many of these older subdivisions were established before planning standards existed and now limit the aesthetic and efficient design of streets and buildings. In some cases, the subdivision exists only on paper.

Replotting schemes might be appropriate for re-orienting streets and lots to maximize the number of properties having a southern exposure. Reducing individual lot sizes or increasing the number of multi-family lots are other examples of replotting schemes which could affect energy use.

Annexation

The regional planning commissions currently play a coordinating role in developing regional policies for growth. Because the RPCs act in an advisory capacity, the member municipalities are not obliged to accept the commission's recommendations. Under the current legislation governing regional planning commissions, consensus on specific policy goals (such as energy conservation) and agreement on the means of implementation is very difficult. Instead of a regional planning commission, a central authority which has policy-making power for the entire area could more easily implement a comprehensive plan to reduce suburban sprawl, realize objectives of balanced growth, and thereby reduce energy use.

In 1980, the Municipal Government Act was amended so that only municipalities can directly apply to the Local Authorities Board for annexation.[81] Developers wishing to have their land annexed for future development could be subject to council-imposed conditions. These conditions could relate to energy considerations such as land use mix, density, and subdivision lay-out.

Planned Unit Developments

A Planned Unit Development (PUD) substitutes the typical one lot-one house development for a unified site plan. This combines several lots and develops a number of homes at one time. A PUD could contain a range of energy conserving design features: narrower streets, clustered housing, zero lot line development, street and lot orientation for solar access, bicycle and pedestrian routes, windbreaks, local amenities, and shopping.[82]

In parts of the United States, PUD and clustering are voluntary provisions within the land use bylaw. Density and floor area bonuses are offered as incentives to adopt PUD and clustering. Those options which result in the greatest energy savings receive the largest bonuses.

Development Agreements

Although each item is negotiable, Council may require the applicant to enter into an agreement to provide as a condition of approval: installation of utilities, road and walkway construction, parking, and loading/unloading areas. Council may require that the developer install these services or pay for equivalent costs. This mechanism, also applicable to off-site or redevelopment levies, could become part of a development agreement.

A municipality could also try to negotiate with the developer for "extra" facilities. For example, landscaping, bike trails and recreation facilities are "extras" that have energy implications which might be negotiated as part of a development agreement. If new bike trails were provided by a developer, the municipality would also have to identify the easements needed to connect major destinations to other bike trails.

Site Plan Reviews

A site plan review is an administrative process used to negotiate the design of developments under PUD, subdivision agreements, and direct control districts. Standards and guidelines for the review are often consolidated in a handbook and are based on environmental, aesthetic and other criteria, but not usually energy. However, there is an opportunity here for introducing energy criteria because this is when negotiation takes place and revisions are still easy at this stage. A site plan review could, for instance, explore solar orientation and street lengths.[83]

Innovative Residential Development Areas

Municipalities may apply to the Minister of Municipal Affairs to have an area designated for innovative residential development. The Minister may waive any requirement or procedure in the Planning Act (including the land use bylaw and subdivison regulations) to encourage low cost, innovative housing. This all-encompassing provision of the Act could be used to encourage energy conserving housing developments, particularly when a 'demonstration' purpose could be served.

Municipal Capital Improvement Plans

The municipality can show energy leadership in land use by adopting energy efficient practices in the planning and provision of public facilities and services. There are opportunities for conserving energy in transportation systems planning, the design and provision of utility infrastructure, and the provision of recreation, park, social facilities and services. Cities such as Edmonton which own their electrical utility have an unique opportunity to implement energy efficient electrical service for the public good.

Significant savings can be realized by implementing many small, incremental changes to improve the efficiency of new buildings and facilities. This can also be accomplished when constructing transportation facilities and infrastructure (such as streets) in new subdivisions.

Direct Financing

The direct financing of development would appear to have the most potential where cities are already major land owners and developers, such as Edmonton, Red Deer, and Lethbridge. Here, the municipalities could implement comprehensively planned, energy efficient subdivisions on the city-owned land. Significant direct energy savings would be possible and would provide the community with a large demonstration project.

High initial capital costs constrain district heating systems compared to decentralized gas heating systems. Generally, municipalities are not in the business of producing and distributing natural gas for home heating (with the exception of Medicine Hat). Natural gas service is usually provided by the private sector. Therefore, their participation would be necessary for a district heating system.

District heating systems are not only at a disadvantage due to the initial capital required, but also because there is a 'lag' before revenue is generated. The problem of 'lag' suggests a new financing role for local governments and public utilities in district heating systems. Finally, the availability of alternate financing (perhaps subsidized by the province) could act as a major lever to introduce energy efficient supply systems, buildings and community design.

Education Programs

The main barriers towards changing municipal energy policies are political ones. If citizens are not interested in and are not demanding change, it will not likely happen. Citizens can become involved in the issue through various avenues of public participation, including elections and the creation of new institutional structures such as cooperatives. For that to happen, leaders are needed to educate citizens and create opportunities for public involvement and debate.

The first step in resolving the problem of energy waste is recognition. Increased recognition can be achieved through environmental education; specifically, promotion of resource management and its three basic principles: everything is related to everything else, the environmental system is a closed system, and pollutants are simply misplaced resources.[84] Environmental education helps avoid 'solutions' to problems, which only relocate the problem, create a new problem, or change the nature of the problem.

Energy-efficient developments which are implemented are probably the most effective educational tools. Here, all participants in the process, including the public, learn from the experience. Mistakes will inevitably be made, but the fact that something is being done seems more important than whether or not it contains flaws. In a conservative political climate, it is vital to have broad public support for energy initiatives, since critics might otherwise destroy the credibility of these initiatives by focussing on weaknesses.

In the field of land use planning and energy, local planners could play a major leadership role. What is evident to the author, however, is a lack of leadership from planners who currently see their roles as advisors and technicians rather than as advocates of new approaches.

Summary of Municipal Role

Legislative authority is unclear in the field of energy and land use. Nevertheless, municipalities should proceed with whatever means are available to them to encourage efficient land development practices within their jurisidictions. Barriers to efficient community design created by existing regulations should be eliminated to permit market forces to allocate resources in an efficient manner.

The energy efficient design of new subdivisions is only one of the energy issues municipalities should be concerned with. Other issues which should be analyzed are:

- in-house conservation programs;
- energy conservation within built-up areas;
- energy conservation in transportation systems;
- development of renewable energy resources;
- methods to encourage waste recycling;
- energy conservation in commercial, industrial, and residential buildings; and
- public education and demonstration projects.

Comprehensive community energy planning goes beyond energy conservation policies implemented through land use and development tools. The local land use planning authority might consider assuming responsibility for preparing an overall 'energy plan', but this likely falls outside their mandate. To ensure it is within their mandate, changes in provincial legislation would be required to broaden the interpretation of the 'planning' function. Until legislation is amended or separate 'energy offices' are created, local planning authorities should evaluate all possible energy issues during the preparation of statutory plans and the normal review of land development.

In the absence of comprehensive energy conservation objectives and planning processes at the municipal level, existing local policy instruments can still be used to implement strategies for energy conservation. Generally, this is achieved through a 'mixed scanning' policy planning approach. This process uses a pragmatic, incremental approach to planning while recognizing the real constraints of the usually preferred rational and comprehensive planning process. In this way, local planning authorities can begin to change existing development standards gradually.

The five most effective municipal policy instruments for saving energy in land use are outlined in Table 14. Area structure plans and subdivision plans are the tools which appear to have the greatest potential impact on energy use in new subdivisions. The land use bylaw is also important for regulating land use for an entire urban area (including newly subdivided lands). Municipal general plans and regional plans are also important for outlining energy conservation objectives, but they lack the detail necessary to implement specific strategies.

Municipalities can use capital improvement plans and the direct financing of development to influence energy use. When a municipality plays the role of developer by directly financing land development, a whole range of energy conservation strategies (within market limitations) can be directly implemented.

Table 14

STRATEGY IMPLEMENTATION THROUGH PRIMARY POLICY INSTRUMENTS

ASP - Area Structure Plans
LUCB - Land Use Control Bylaw
DF - Direct Financing
SP&R - Subdivision Plans and Regulations
CIP - Capital Improvement Plans

ELEMENTS OF DESIGN STRATEGIES		POLICY INSTRUMENT				
		ASP	SP&R	LUCB	CIP	DF
1. ENVIRONMENTAL SITE FACTORS	- Site selection	X	X			X
	- Solar access	0	X	X	0	X
	- Windbreaks for buildings	0	X	0	X	X
	- Snow management	0	X	0	X	X
2. DENSITY	- Attached housing	X	X	X	0	X
	- Spatial distribution	X	X	0	0	X
	- Lot sizes	0	X	X		X
	- House sizes			X		X
	- Population/dwelling			X		
	- Streets, parking, parks	0	X	X	X	X
3. BUILDING AND LAND USE MIX	- Local commerce	X	0	X		X
	- Local recreation	X	X	X	X	X
	- Local employment	X	0	X		X
	- Multi-use buildings			X	X	X
4. DISTRICT HEATING	- Locate subdivision & fuel source close by	X	0	X	X	X
	- Compact, dense develop.	X	X	X	0	X
	- Protect rights-of-way	X	X		X	X
	- Heat system conversion		0	X		X
5. TRANSPORTATION	- Public transit routing	X	X		X	X
	- Protected waiting areas		0	0	X	X
	- LRT alignment	X	X		X	X
	- LRT intermodal links	X	X		X	X
	- Roadway lengths, widths	X	X	X	X	X
	- Parking standards		0	X	X	X
	- Rear alleys	0	X	X	X	X
	- Pedestrian environment	X	X	X	X	X
	- Accommodating bicyclists	X	X	0	X	X
	- Inter-city intermodality	0	0		X	X

Legend: X - Potential Major Influence
0 - Potential Minor Influence

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